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ABSTRACT

This study was undertaken as a part of the continuing oversight of the National Science Foundation by the Subcommittee on Science, Research and Technology of the Committee on Science and Technology of the House of Representatives. In addition, the study was intended to examine recent criticisms of the Foundation's pre-college science education programs. This report describes and analyzes: (1) the reasons for NSF's involvement in education apart from research as it pertains to this issue; (2) the events and issues which have affected the growth of the NSF pre-college programs, especially as reflected by the interests of the Congress and the executive branch; (3) the accomplishments of NSF in this field; and (4) the evolution of the structure of the pre-college programs to date. The study was based primarily on an extensive review of hearings testimony, of the publications of NSF and of additional materials referenced by public documents. (Authors/MH)

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THE NATIONAL SCIENCE FOUNDATION AND PRE-COLLEGE SCIENCE EDUCATION: 1950–1975

REPORT

PREPARED FOR THE

SUBCOMMITTEE ON SCIENCE, RESEARCH,
AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
NINETY-FOURTH CONGRESS

SECOND SESSION

BY THE

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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C., January 22, 1976.

Hon. OLIN E. TEAGUE,
Chairman, Committee on Science and Technology,
House of Representatives,
Washington, D.C.

DEAR MR. CHAIRMAN: Last June, as part of this subcommittee's oversight responsibilities of the National Science Foundation, I requested the Congressional Research Service to undertake a comprehensive review of the Foundation's pre-college education support activities—past and present.

I felt there was a need for a study relating:

1. The reasons for NSF's involvement in this level of education apart from research as it pertains to this issue;
2. The events and issues which have affected the growth of the NSF pre-college programs, especially as reflected by the interests of the Congress and the executive branch;
3. The accomplishments of the National Science Foundation in this field; and
4. The evolution of the structure of these programs to date.

It is my belief that this report has accomplished the mission it was designed to do and that it will be of marked value not only to the subcommittee and the full committee, but to all Members of Congress and the Foundation as well.

Sincerely,

JAMES W. SYMINGTON,
Chairman, Subcommittee on Science, Research and Technology.

LETTER OF SUBMITTAL

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Washington, D.C.

HON. JAMES W. SYMINGTON,
Chairman, Subcommittee on Science, Research and Technology, Committee on Science and Technology, U.S. House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I am pleased to forward with this letter a report entitled "The National Science Foundation and Pre-College Science Education: 1950–1975," prepared at the request of the Subcommittee on Science, Research and Technology.

This study examines the situations and events which led the National Science Foundation into an involvement with educational activities and with the teaching of science at the pre-college level, and which have shaped the Foundation's educational programs at the pre-college level over the past 25 years. In accord with your request, this study is intended to relate:

1. the reasons for NSF's involvement in this level of education and for its involvement in education apart from research as it pertains to this issue;
2. the events and issues which have affected the growth of the NSF pre-college programs, especially as reflected by the interests of the Congress and the Executive Branch;
3. the accomplishments of the National Science Foundation in this field; and
4. the evolution of the structure of these programs to date.

This study was conducted by Dr. Langdon T. Crane, Specialist in Science and Technology and Head of the Management and Policy Sciences Section of the Science Policy Research Division. The manuscript was reviewed by Mr. Walter A. Hahn, Assistant Chief of the Science Policy Research Division and Senior Specialist in Science and Technology.

On behalf of the Congressional Research Service, I would like to express my appreciation for the opportunity to undertake this timely and challenging assignment.

Sincerely,

NORMAN BECKMAN,
Acting Director.

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THE
NATIONAL SCIENCE FOUNDATION
AND
PRE-COLLEGE SCIENCE EDUCATION
1950–1975

EXECUTIVE SUMMARY

This study was undertaken as a part of the continuing oversight of the National Science Foundation by the Subcommittee on Science, Research and Technology of the Committee on Science and Technology of the House of Representatives. In addition, the study was intended to examine recent criticisms of the Foundation's pre-college science education programs. The objectives of the study were to describe and analyze:

(1) the reasons for NSF's involvement in the pre-college level of education and specifically its involvement in education apart from research as it pertains to this issue;

(2) the events and issues which have affected the growth of the NSF pre-college programs, especially as reflected by the interests of the Congress and the executive branch.

(3) the accomplishments of the National Science Foundation in this field; and

(4) the evolution of the structure of the pre-college programs to date.

The study was based primarily on an extensive review of hearings testimony, of the publications of the National Science Foundation, and of additional material referenced by public documents.

The National Science Foundation's pre-college science education programs have generally received high praise for their accomplishments. Among the Foundation's many pre-college education activities, two programs would seem to have been of particular value from the standpoint of national impact.

The first of these has been the institute program, under which NSF has provided grant support to colleges and universities for science faculty to instruct pre-college teachers in science and in science curricula. Prior to recent reorganizations, there were basically three types of institute format:

(1) *Summer institutes:* offered instruction at a university under a summer-school format, and provided a small personal-subsistence stipend for most of those who attended;

(2) *Academic year institutes:* offered special science courses, generally designed as part of an advanced degree program, at universities during the academic year for teachers on leave from their regular employment (a stipend was provided to provide partial salary recovery); and

(3) *In-service institutes:* offered science and science curriculum instruction during the school year during non-school hours.

It would seem, from the comments of a number of people who studied the changes and improvements in American pre-college education in the early 1960's, that the contributions of NSF were impressive in overcoming deficiencies in science education in the post-Sputnik era. In his well-known 1963 study of problems in pre-college education. James Bryant Conant, former president of Harvard University, said of the NSF institutes:

> The use of summer institutes for bringing teachers up to date in a subject-matter field has been perhaps the single most important improvement in recent years in the training of secondary school teachers.[1]

Those who dealt with college-level students had much the same impression. Dean B. Roger Ray of the Division of Sciences, Washington State University, Pullman, Washington commented in 1964 as follows:

> The Institute Program has been more responsible than any other factor in achieving a substantial up-grading of competence of science and mathematics teachers in secondary schools. I believe it has been the primary factor. We continually see the results in general and specific ways. Each freshman class in the University is better prepared in science and mathematics than the previous one, for instance, as shown by our Mathematics Placement Test scores. These students are getting instruction in their basic high school courses that is more substantial and modern. We have an increasing number of freshmen who obtain advanced placement, in good part because additional science beyond the minimal requirement is being offered in the high schools by competent teachers. Frequently we can correlate the quality of the work given in a high school with a specific teacher who has participated in the Institute Program.[2]

In 1965, Francis Keppel, United States Commissioner of Education expressed similar views:

> Classroom teachers, as we all know, face tests as well as give them. Perhaps the greatest test is that of adapting to the bewildering pace of change.
>
> Teachers must provide instruction geared to educational needs that break sharply with tradition. They must respond to a new sense of social and economic values. They must keep abreast of constant expansion of the store of knowledge that is to be transmitted in the classroom. Changes of these kinds have particularly challenged teachers of science and mathematics—subject areas that have been most pervasively revolutionized in recent times.
>
> The challenges are being met, and the institutes programs administered by the National Science Foundation have made a major contribution to our success. Through these institutes, teachers have become familiar with recent advances in their special fields of knowledge. They have familiarized themselves with new courses of study. They have developed new approaches to learning and teaching—benefitting not only themselves and their students but inspiring their fellow teachers as well.
>
> Beyond these accomplishments, the NSF institutes program has demonstrated that Federal efforts can produce substantial educational improvement. Its success has led to the development of similar institutes in other subject fields and it has taught the important lesson that the quality of education in the classroom is amenable to swift improvement by concentrating on the competence of the classroom's centrally important figure—the teacher."[3]

Until rather recently, the emphasis of the institutes programs was primarily on raising teacher competence. Though the sheer magnitude of the number of elementary school teachers needing science training required the development of a school-oriented approach at that level, high school teachers could generally apply to attend summer and in-service institutes without formal permission by their school supervisors.

The summer and in-service institutes offered courses that were usually available on an individual basis. The academic year institutes were generally designed to be part of a program leading to a master's degree. Teachers were admitted to such programs under formal arrangements whereby they would take a sequence of courses in various institutes to qualify for the degree. At their peak, over 2000 teachers would receive master's degrees each year under such "sequenced programs".

---

[1] Conant, James Bryant. The Education of American Teachers. New York. McGraw-Hill Book Co., Inc. 1963. p. 207, 8.

[2] As quoted in Kreighbaum, Hillier and Rawson, Hugh. An Investment in knowledge. New York. New York University Press. 1969. p. 310.

[3] As quoted in Kreighbaum and Rawson, p. 308.

The second major activity has been curriculum development. Under this program, which began in 1956, many eminent scientists have worked under NSF sponsorship to upgrade old methods of instruction, and to provide new and scientifically accurate curricula for use in pre-college classrooms.

Beginning in about 1970, NSF began to change the institute format in a fundamental way. Instead of maintaining the focus on the individual betterment of science teachers, the institutes became a mechanism to aid individual schools, or groups of schools, to adopt new science curricula. This new activity was termed *curriculum implementation*, and was structured into a sequence of three operations which could be described approximately as follows:

(1) workshops to acquaint school administrators with a selection of science curricula for possible use in their schools or school districts;

(2) instruction for selected personnel to use tentatively selected curricula on an experimental basis; and

(3) the training of key personnel for the instruction of other science teachers in each school.

A fourth form of institute was still available for the general training of teachers, but like the other later forms of institutes this one focused on curricula rather than upon disciplines. By FY 1974, there apparently were no longer any institutes to help teachers master a discipline, only institutes to instruct in curricula.

During the middle and late 1960's, NSF began to support development of curricula outside of the mathematical, physical, and engineering sciences. These curriculum development projects were carried out under the principles that NSF had originally devised to offer insurance against Federal domination of curriculum content:

(1) NSF only responded to curriculum development proposals. It did not direct attention to areas or fields.

(2) Though curriculum proposals were evaluated whenever a grant was to be made, NSF did not seek to evaluate or to revise curricula developed under its support.

(3) The completed material remained in the hands of the developer, and though NSF did aid in transfer of the material to publishers and did maintain control of certain financial and administrative matters, it purposely did not take possession of the material so as to avoid any appearance of influence on the content, or any approval or disapproval of any part of the curriculum.

Such management principles seem to have answered the need to avoid Federal control of curriculum content, but in adopting this approach the Foundation had no way to ensure the public acceptability of the content of curricula developed under Federal support.

In the spring of 1975, NSF's pre-college education activities attracted attention in consequence of material contained in a fifth-grade social studies curriculum entitled *Man: A Course of Study* (MACOS).

MACOS had been developed with NSF support, starting in 1964, under the design of Jerome S. Bruner, director of Harvard University's Center for Cognitive Studies. The course was structured to use films and short pamphlets to indicate how and why humans behave differently than animals. Instruction consisted of class discussions in which individual students would, on the basis of the material presented, seek their own answers to three questions:

(1) What is human about human beings?
(2) How did they get that way?
(3) How can they be made more so?

The course began with an extensive presentation of animal behavior, and then proceeded to study the culture of a primitive eskimo tribe, the Netsiliks. The selection of this particular culture for study seemed to have a definite pedagogical purpose. The necessities of survival in the hostile polar climate had demanded that the Netsiliks, and presumably most other eskimos, adopt a number of practices which might be regarded as inhumane and/or totally unacceptable in societies under less pressure for survival. The purpose behind this selection of material seems to have been to help students to understand that man's human characteristics are distinct from the culture which circumstances might force him to adopt. The idea would seem to be an important concept in understanding certain areas of modern thinking in the social sciences.

While the scientific integrity of MACOS seems to have been reasonably assured, and while the pedagogical approach may have had some valuable features, some of the material in the course drew criticism as being either offensive or unacceptable for presentation to children. Among those who objected to MACOS, a concern was expressed that 1) the Federal government was developing objectionable curricula for use at the pre-college level and 2) the Federal government was promoting the adoption of MACOS and possibly other Federally sponsored curricula through the NSF implementation programs.

The criticism of MACOS attracted a good deal of attention, both in the House of Representatives and in the Senate, during consideration of the NSF authorization and appropriation for FY 1976. The House Committee on Science and Technology initiated two studies, one to be performed by a committee-appointed panel of citizens and the other to be performed by the General Accounting Office. On the Senate side, the Special Subcommittee on the National Science Foundation of the Committee on Labor and Public Welfare held a full day of hearings on MACOS and related matters. This congressional concern was one of the factors in the adoption of an amendment in the House to the NSF authorization bill, requiring that the Foundation submit all proposed grant actions to the Congress for its consideration for 30 days, during which Congress might disapprove NSF's intended support.

Though this amendment was not retained in the ultimate authorization legislation, the appropriation act for FY 1976 specifically eliminated funds for curriculum implementation at NSF.

The Foundation responded to the criticism with an internal study of its management of curriculum development. The recommendations of its study generally favored more extensive review, by outside panels, of curriculum development proposals and of subsequent developed curricula. The recommendations did not mention a possible need for greater internal NSF capability for independent review, and possibly for control of curriculum development, in order to direct, augment, and implement the work of these advisory panels.

At the request of the internal study group at NSF, the National Science Board, a presidentially appointed group of 24 eminent persons having responsibility for the policies of the Foundation, issued on June 20, 1975 three policy statements relating to curriculum development and implementation. These included the following points and discussion:

On pluralism in education:

"To ensure that Federal funds do not directly or inadvertently lead to the development of a monolithic curriculum structure, and to ensure the diversity that society requires, the following procedures are recommended.

1. The National Science Foundation should carry out a broad-based analysis of future needs in subject areas and publicize such needs.
2. The Foundation should ensure competitive selection of project developers addressing these needs.
3. It should encourage development of alternatives by NSF.
4. The Foundation should establish administrative procedures in the implementation stage that will avoid any appearance of indoctrination or coercion."

On curriculum development:

"The National Science Foundation has a continuing role in the development of course materials and teaching methods in the mathematical, physical, medical, biological, engineering, social, and other sciences at the pre-college level. The Foundation can and should make a unique contribution by bringing new, intellectually challenging science content and teaching methods to elementary and secondary school students and their teachers. The program should be broadly aimed at encouraging future scientists and technologists as well as increasing the quality of science education available to all students at the pre-college level."

On curriculum implementation:

"Prior to undertaking full-scale dissemination and assistance activities for NSF-developed materials, NSF should undertake a careful review to ensure that the proposed subject matter fits within reasonable limits [illegible] norms with respect to educational value and that the scientific content is accurate. Recognizing the broad base of concern with elementary and secondary education, the Foundation should provide opportunities for input in this review by representatives of the scientific, educational, child development, commercial publishing, and informed public communities."

However, the Board did not seek to reduce NSF's dependence on outside judgment and review, and on outside decisionmaking. The dependence on external advice and leadership may have been an important factor in the development of the MACOS problem; and this dependence would seem to have merited consideration in view of specific recommendations from the House Committee on Science and Astronautics (1966) and from the NSF Advisory Committee on Science Education (1970) that the Foundation staff play a less passive role.

The history of NSF's activities in pre-college education indicates that, while NSF would seem to have played an essential role in attracting scientists into the institutes and into curriculum development programs, the primary impetus for the creation, design and growth of the pre-college programs came from outside of the Foundation.

In the early 1950's, during its formative years, the Foundation received continuing advice from its own staff as well as from numerous outside scientists that the poor quality of high school science education was a major problem, if not *the* major problem, in science education. Yet the Foundation declined proposals seeking support for seminars, workshops, or institutes for high school science teachers on the basis that the needs of graduate education and research did not allow support for such pre-college efforts. Support for such undertakings continued to be declined until a proposal, seeking support for a summer institute for high school science teachers to be held in 1954, arrived with the endorsement of a committee of the National Academy of Sciences/National Research Council.

The first strong escalation of the NSF pre-college program resulted from the concerned interest of President Eisenhower, who formed a cabinet-level committee in 1954 to examine reports of rapidly growing strength in the technical training activities of the USSR. The committee recommended in October 1954 that NSF ". . . emphasize programs within its responsibility which will contribute to a solution of the problem and provide leadership to other departments and agencies in developing plans and activities which will contribute to a solution of the problem." The NSF responded by doubling its planned expenditure of $150,000 for science education in FY 1955, and by obligating almost $1.5 million to science education in FY 1956.

Congressional interest in science education, particularly at the high school level, began to appear following the publication in July 1955 of Nicholas DeWitt's study of Soviet professional manpower. The latter stages of this work had been supported by NSF. On the basis of that report the House Committee on Appropriations recommended that NSF's budget for the institutes in FY 1957 be almost tripled, to a total of $9.5 million. The Foundation unsuccessfully opposed the increase in the Senate when it became apparent that some of this increase might have to be obtained from the increases requested in the research budget. The $9.5 million was earmarked in the appropriation act, but was able to be absorbed in the NSF budget without apparent damage: research was still accorded a 110% increase in budget.

The advent of Sputnik in October 1957 resulted in a series of strong increases for science education, the budget for which amounted to $64 million in FY 1959.

The NSF education budgets continued to escalate through the early 1960's, and eventually reached a high plateau of almost $125 million in Fiscal Years 1966, 1967, and 1968. However, the Foundation's interest in pre-college education diminished following the issuance of a report by the President's Science Advisory Committee in 1962 recommending a doubling of science Ph. D. output by 1970. Following this report, NSF mounted its Science Development Program aimed at doubling the number of institutions offering top-quality graduate science education. The first awards were made in 1965.

Simultaneously, NSF reoriented its education programs to focus on graduate education problems. In 1964 it mounted an ambitious program of graduate traineeships to augment the older graduate fellowships.

After 1965 the institutes' budgets began a decline from a maximum of about $43 million to a level of about $15 million for FY 1974, with an additional $2 million in a companion program called the Cooperative College-School Science Program.

In recent years, at least since 1970, two factors seem to have influenced the pre-college programs. Both are difficult to substantiate concretely. The first is a reported antipathy by the Office of Management and Budget toward forms of activity that might be classed as continuing aid to education. According to these reports, OMB has taken the position that it might be acceptable to undertake specific projects to aid pre-college schools, but the repetitive support of activities, such as discipline-oriented summer institutes, was to be discouraged.

The second factor influencing NSF's pre-college activities seems to have been a growing concern among its administration, and among the members of the National Science Board, about competing needs for funds, particularly the growing problem of sufficient funding for university research programs. These concerns seem to have led the Foundation to place an even lower priority on pre-college education, as two Board members indicated in testimony to the House Committee on Appropriations for FY 1974.

Subsequent to 1970, NSF reorganized and reprogrammed its pre-college education activities along lines that appear to have been in accord with the interests of the Board and the OMB. In doing so, NSF made the argument that the discipline-oriented institutes were no longer effective: 50% of the high-school science teachers had attended one institute or more so that current attendees were primarily "repeaters"; and the other 50% did not seem interested in attending, so the original institute format was no longer useful. The argument apparently lacked foundation, however, for no attempt seems to have been made to verify the 50% attendance figure or to ascertain why so many teachers still seemed to want to attend institutes. Had a detailed study been done, the need for the institutes might have appeared to be greater. An informal survey by an NSF staff member in 1970 indicates that there may have been a significantly greater proportion of "first-time" attendees in summer institutes than NSF arguments had indicated.

The NSF arguments were not seriously challenged in Congressional budget hearings. The Foundation proceeded to re-program its pre-college institutes (and related activities) around 1) curriculum instruction for teachers, and 2) the implementation of curricula in specific schools or school systems. These activities, which were designed to stimulate the adoption of improved curricula, were said to provide a more direct means of dealing with deficiencies in pre-college instruction. On the other hand, there were no longer any discipline-oriented institutes under the new format, nor was it possible for teachers to study for advanced degrees through the institutes.

With the new focus on curricula, the institutes probably lost some of their attractiveness to highly-motivated teachers who wanted to master additional subject areas, or simply to "brush-up" in a field they had mastered previously. It thus may be that the institutes are now less useful to teachers who are re-assigned to new courses and must master a new subject. Questions of this sort merit study.

At this writing, the Foundation would appear to be faced with a policy dilemma. Its recent curriculum inplementation activities might be questioned on the basis of Federal influence in local school affairs. On the other hand, prior to the implementation programs the new curricula were not adopted at the rate NSF deemed appropriate. Similarly, NSF has felt that it must play a completely passive role in curriculum development, yet in doing so it has been criticized for curriculum content.

These two problems seem to pose great difficulty for NSF, which apparently feels that important principles are at stake: 1) the new curricula ought to be put to use and 2) the Federal government ought not to influence curriculum content.

NSF's positions regarding these two matters seem to create a paradox in its basic policy approach. On the one hand, NSF has become heavily involved in encouraging local schools to adopt new curricula, while insisting on the other hand that a similar degree of NSF involvement in decisions regarding the content of the curricula it develops would be wholly inappropriate. Judging from the recent policy statement (quoted above) of the National Science Board regarding curriculum implementation, it would appear that the Board may sense some of the difficulty in its former policies relating to curriculum content. However, a number of questions about the curriculum implementation activities and about the former institutes programs have yet to be addressed by the Board.

It is possible that, had the National Science Board examined these areas of NSF activity from a broader perspective, NSF programs and management might have been modified to avoid recent criticisms and to be of greater benefit to the needs of the pre-college community. In light of the recent problems, it may be worth examining the effectiveness of the Foundation's policymaking machinery. There seems to be little ready explanation why the Board, after some twenty years of cautionary advice by Members of Congress to avoid influencing local school affairs and to be wary of the problems that could arise from controversial curricula, 1) apparently did not reexamine its policies on curriculum review, and 2) apparently allowed NSF to mount its effort in curriculum implementation without announcing new and detailed policy guidelines. Even with congressional advice, the Board did not anticipate the problems that arose, and in that sense it may not have been effective as a policymaking body.

There would also seem to be reason to inquire why the National Science Board allowed such extensive revision of the former institutes programs 1) without a thorough statistical examination of the functions that the institutes had been serving, and 2) without attempting some assessment of their future value. NSF officials report that there are almost no data available for making such an analysis, and so there would seem to be a question of why the Foundation was allowed to discontinue these highly praised institute activities. Even at this late date, it would be interesting to have a statistical review of the role those institutes played, so as to understand whether current implementation efforts are fully adequate in meeting the needs for pre-college science teacher instruction.

A review of the public record suggests that the National Science Board may not have paid continuing attention to many important matters affecting the pre-college programs. It may be that the National Science Board is no longer able to monitor the full range of NSF activities and that, with its own objectives and priorities, it may have become a complicating factor in the necessary interplay between NSF, the Congress, and the Office of Management and Budget.

There are now indications that the Congress may seek ways to legislate certain critical aspects of NSF operation. In consequence of the MACOS issue, the House approved an amendment to the NSF authorization requiring that all intended grant actions be submitted by NSF for congressional consideration. Though this amendment was not retained in the final legislation, it would seem to have been evidence of doubt about NSF policies.

Most recently, companion bills have been introduced in the House and Senate to legislate methods by which proposals are reviewed by NSF. These measures would seem to represent an unusual degree of congressional involvement in the operation of a Federal agency and would, in that sense, appear to lie beyond the traditional role of congressional oversight—agency accountability. Considered in that light, they would seem to be strong indicators of congressional concern about certain policies of the National Science Foundation.

INTRODUCTION

A. THE ISSUE TODAY

In the course of its 25-year history, the National Science Foundation has developed a deep and abiding commitment to pre-college science education. Recent criticisms of the Foundation's educational activities at this level, particularly of NSF's efforts to promote and facilitate the adoption of improved science curricula in elementary and secondary schools, raise serious questions about how NSF became involved in these activities and whether its participation at this educational level is necessary. At the heart of this issue is the question of whether the Foundation is promoting development of science curricula and then is encouraging local school systems to adopt them. Since pre-college public school systems are generally regarded to be under local community control—albeit with a good deal of state regulation and/or influence in many cases—the question of overt Federal involvement in school affairs is an important, and often highly emotional, issue.

This study attempts to examine (1) the reasons for NSF's involvement in pre-college education; (2) the national issues which mandated this involvement under the guidance of Congress; and (3) the general structure and philosophy of its current efforts. It is intended to provide an understanding of the circumstances which have led to recent criticisms of NSF's curriculum implementation efforts, rather than to delve deeply into the specifics of particular curricula and whether various criticisms of those curricula are valid. The intent is to illuminate the Foundation's achievements and contributions, as well as its past managerial shortcomings, in the expectation that such information will be useful in considering how NSF's future activities in pre-college education might best be structured.

B. A BRIEF OVERVIEW

Created in 1950 in consequence of the impressive technological successes during World War II, successes which indicated the great importance of science to the well-being and vitality of the United States, the National Science Foundation was assigned the task of improving the nation's potential in scientific research and in science education. Though it was first expected that the Foundation would limit its educational programs to providing fellowships and stipend support to graduate students, in the opinion of the NSF management it became clear almost immediately that science teaching had to be improved at the college level. Summertime instruction for college faculty at specially designed "institutes" held at universities and taught by graduate faculty became the vehicle for this effort to improve undergraduate education. For 1953, the second year of operation of this college-level institute program, the director of one of the institutes requested additional support to include high school teachers in his program. Although NSF declined to support this request, funds were able to be obtained from private sources for an experimental effort to instruct high school science teachers.

The results were sufficiently encouraging that the Foundation adopted the program on an experimental basis in the following year. Shortly thereafter, in 1954, international competition in technology began to appear. First came reports that the USSR was producing more scientists and engineers than the United States. By 1956 the public had become generally aware of the problem through a book titled "Soviet Professional Manpower" by Nicholas DeWitt.[1]

Then the great surprise of the Sputnik launch in 1957 galvanized the United States into action to acquire and maintain a clear superiority in science and technology. Congress responded in the first instance by increasing NSF's requested budget for improvement of high school science teaching from $3.85 million to approximately $9.5 million for the Fiscal Year 1957 and mandating that all of the money be spent. By this time the institute program had grown to include both academic year and summer programs for high school teachers.

Following Sputnik, the Fiscal Year 1959 budget for improvement of high school science teaching jumped to over $35 million. There was no longer any question about whether NSF had been given a responsibility for pre-college education in science. Congress was later (1972) to amend the National Science Foundation Act of 1950 to say explicitly that NSF was responsible for science education "at all levels". However, the National Science Board repeatedly expressed concern that science education, particularly pre-college education, might "unbalance" its overall program to develop science. Since it happened that on several occasions the Congress increased the NSF education budget at the expense of the research budget, the reaction of the National Science Board may not have been entirely unreasonable.

But whatever the opinion of the Board, the Foundation itself seems to have been aware of certain of the potential problems that their pre-college education programs might have created, and appears to have welcomed innovations which would improve the program. In the former respect, NSF seems to have been careful to administer its program so that the initiatives and the selection of material for any particular institute program were entirely in the hands of the people who would run the institute. Since institutes generally served a local clientele, the selection of subject, the level of offering, and the choice of curriculum reflected the expressed desires and needs of the schools in the local geographic area. Thus, it seemed that the Federal government could not be accused of meddling in the decisions of local school boards. In the second respect, the Foundation's pre-college education program has changed considerably with the passage of time in an attempt to have a meaningful impact on a teacher population that was too large to reach with direct instruction in institute classrooms.

As long as interest was limited to high school science teachers, there was some hope of dealing more or less directly with a considerable fraction of those who needed instruction. But when it became evident that the poor quality of science training at the elementary level was a serious impediment to later study in science, the Foundation had to learn to deal with an enormous number of teachers in an effective way.

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[1] DeWitt, Nicholas. Soviet professional manpower: its education, training, and supply. National Science Foundation. U.S. Govt. Print. Off., Washington, D.C. 1955. 400 p.

Eventually the Foundation began to support institutes that would (1) teach administrators about available choices for new and improved curricula, (2) train selected teachers in a school or district in a curriculum to be tested, and (3) then instruct teachers in a school or district to teach other teachers to use the new curriculum. In addition, the Foundation expanded its program to support development of new and improved curricula for instruction at all levels.

One very positive aspect of these activities was the increased communication between graduate school research faculty and those who teach at lower levels. Science education, particularly at the formative stages, seems to require considerable care in order to inculcate the necessary abilities for observation, analysis, and abstract thought. Through its connection with the research community, NSF was able to interest some of the best research minds in the country in the subtleties and content of pre-college science education. Through NSF, research people became involved in creating new instructional curricula, and in instructing teachers about the new curricula, and about the most modern methods of teaching science. Old barriers to communication disappeared in this common effort, to the apparent betterment of science instruction at all levels.

In the midst of apparent success in this comprehensive effort, NSF has recently come under severe attack because many of the curricula which it developed have been featured for instruction in the institutes' programs. Although the content of any given institute program is selected by the institute director in concert with the university or college whose facilities will be used, and even though this selection is made independently on the advice of the schools and school administrators in the immediate locality, it would still be possible for NSF to exert influence through its selection of which institutes are to be awarded operational support. The concern seems to be that, directly or indirectly, NSF may be developing curricula of a sort that its staff feels should be used, and then may be inducing school administrators to adopt these materials.

Stated somewhat differently, the issue is whether the Federal government should have any hand in curriculum development and, ultimately, curriculum adoption in pre-college schools. Specific objections have been directed both at the possibility of undue influence of the Federal government in local affairs, and at the content of various curricula in the social and life sciences. The Foundation has replied by attempting to show that it has presented a reasonably comprehensive overview of all major available curricula in those institutes which are offered to help administrators and key school personnel to make initial decisions about curriculum selection. NSF therefore feels that any preference for its material, or the selection of any controversial material, by directors of institutes for the instruction of teachers can only reflect the prior curriculum selections made by the local school administrators.

The National Science Foundation concludes that, while local school systems may have some serious problems of community relations, NSF curricula are highly regarded by school administrators and teachers, and that its efforts in curriculum development have been of high quality. NSF adds that the curricula which have been criticized are carefully designed to allow the deletion of material which a local school wants to omit. Thus, the Foundation feels that any problems are in the local selection process.

These are not the only issues relating to the NSF pre-college education program. However, the purpose of this paper will be to show how the NSF pre-college education effort was developed and managed, rather than to analyze specific questions about various curricula. It is hoped that this background and historical description will be useful to those who are interested in national policy questions relating to this issue and who want to consider how the management of NSF's Education Directorate might be improved.

I. GENERAL BACKGROUND AND EXECUTIVE POLICIES RELATING TO EDUCATION PROGRAMS OF THE NATIONAL SCIENCE FOUNDATION

A. THE MISSION OF NSF

The National Science Foundation is now celebrating its 25th year as the principal benefactor and promoter of basic science in the Federal government. It is, of course, not the only agency involved with the performance and support of basic science. Compared to the history of some 100 years of research activity in the Department of Agriculture, which began shortly after its establishment by Congress in 1862,[2] the National Science Foundation has barely reached maturity. And compared to the totality of research support by other agencies in the Federal government, the Foundation's budget is not very significant. This is true even in the more limited arena of university research support, where NSF only contributes about 20% of the total Federal outlay according to recent statments of its director, H. Guyford Stever.

However, age and size are not complete indicators of importance. In its organic act,[3] NSF has been given responsibility:

> To initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels in the mathematical, physical, medical, biological, engineering, social, and other sciences, by making contracts or other arrangements (including grants, loans, and other forms of assistance) to support such scientific and educational activities and to appraise the impact of research upon industrial development and upon the general welfare.

The National Science Foundation is thus responsible for the health and capability of science in the United States. It is to ensure that science is available as a vital resource to the Nation, rather than to have primary responsibility among Federal agencies for the performance of research in all sectors of national need. While the Foundation is necessarily heavily involved in supporting a wide variety of research, and is concerned about all aspects of the entire national activity in research, both public and private, NSF is often described as a "balance-wheel" whose activities complement those of other Federal agencies. The focus is thus upon "scientific research *potential*" (emphasis added), meaning that the Foundation is to ensure that United States science is aggressively examining new fields for understanding, is creating new techniques for research, and is able to maintain a broad spectrum of activity from which new ideas will evolve; ideas that will lead to new applications.

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[2] See, for instance, DuPree, A. Hunter. Science in the federal government. Cambridge, Mass. Harvard University Press, [1957] 460 p.

[3] The National Science Foundation Act of 1950. (P.L. 507-81st Congress; 64 Stat. 149; as amended).

B. *SCIENCE—THE ENDLESS FRONTIER:* UNIVERSITY RESEARCH AND TEACHING

The philosophy underlying this operation was forcefully and explicitly set forth by Vannevar Bush in his report to the President in 1945 on a program for postwar scientific research. This report had been commissioned in 1944 by President Roosevelt, who had realized the importance of science to the war effort, and who had created a special organization for scientific research and development prior to the entry of the United States into World War II. Bush's report was to outline the importance of scientific research to the peacetime needs of the Nation. Its title was dramatically descriptive: "Science—the Endless Frontier." [4]

As envisioned by Bush, whose conclusions were predicated on the advice of four advisory committees consisting of very distinguished leaders from many segments of the university industrial and research worlds, the ultimate need and justification for a strong national research effort derived from its ultimate (not necessarily immediate) importance to the economy, to the eradication of disease, to the creation of new jobs and new products, and to the national security. The arguments and statements of this report seem as pertinent today as they were in 1945:

> *Science and jobs*
>
> One of our hopes is that after the war there will be full employment, and that the production of goods and services will serve to raise our standard of living. We do not know yet how we shall reach that goal, but it is certain that it can be achieved only by releasing the full creative and productive energies of the American people.
>
> Surely we will not get there by standing still, merely by making the same things we made before and selling them at the same or higher prices. We will not get ahead in international trade unless we offer new and more attractive and cheaper products.
>
> Where will these new products come from? How will we find ways to make better products at lower cost? The answer is clear. There must be a stream of new scientific knowledge to turn the wheels of private and public enterprise. There must be plenty of men and women trained in science and technology for upon them depend both the creation of new knowledge and its application to practical purposes.
>
> More and better scientific research is essential to the achievement of our goal of full employment.[5]
>
> *The Importance of Basic Research*
>
> Basic research is performed without thought of practical ends. It results in general knowledge and an understanding of nature and its laws. This general knowledge provides the means of answering a large number of important practical problems, though it may not give a complete specific answer to any one of them. The function of applied research is to provide such complete answers. The scientist doing basic research may not be at all interested in the practical applications of his work, yet the further progress of industrial development would eventually stagnate if basic scientific research were long neglected.
>
> One of the peculiarities of basic science is the variety of paths which lead to productive advance. Many of the most important discoveries have come as a result of experiments undertaken with very different purposes in mind. Statistically it is certain that important and highly useful discoveries will result from some fraction of the undertakings in basic science; but the results of any one particular investigation cannot be predicted with accuracy.

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[4] Bush, Vannevar. Science—The Endless Frontier, Washington, D.C. National Science Foundation publication 60-40, [1960] 220 p.

[5] Bush, Vannevar, ibid., p. 18.

> Basic research leads to new knowledge. It provides scientific capital. It creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science.
>
> Today, it is truer than ever that basic research is the pacemaker of technological progress. In the nineteenth century, Yankee mechanical ingenuity, building largely upon the basic discoveries of European scientists, could greatly advance the technical arts. Now the situation is different.
>
> A nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill.[6]
>
> *The War on Disease*
>
> The striking advances in medicine during the war have been possible only because we had a large backlog of scientific data accumulated through basic research in many scientific fields in the years before the war.
>
> Progress in combating disease depends upon an expanding body of new scientific knowledge.[7]
>
> Notwithstanding great progress in prolonging the span of life and in relief of suffering, much illness remains for which adequate means of prevention and cure are not yet known. While additional physicians, hospitals, and health programs are needed, their full usefulness cannot be attained unless we enlarge our knowledge of the human organism and the nature of disease. Any extension of medical facilities must be accompanied by an expanded program of medical training and research.[8]
>
> *The Importance of Research to National Security:*
>
> Military preparedness requires a permanent independent, civilian-controlled organization, having close liaison with the Army and Navy, but with funds directly from Congress and with the clear power to initiate military research which will supplement and strengthen that carried on directly under the control of the Army and Navy.[9]

This report became the principal public document upon which the National Science Foundation was later established. It served to show that scientific research was as necessary in peacetime as in war. It also pointed out that basic science is not a field that lends itself to overt management and organization, depending as it does upon the inspiration of its practitioners to carry the work forward. As the report made clear, science is not susceptible to explicit objectives and timetables; nor is one able to predict where progress will first be made, or what piece of new understanding will be the key to unlock a particular problem, or what the utility of a new discovery may prove to be. All that can be said is that technical progress can only come if there is a large storehouse of scientific information available to those who need it, a storehouse of information acquired primarily for the sake of knowledge and understanding. Bush was very worried about the depletion of this storehouse by the demands of World War II, and called attention to the need for a continuing inflow of new information in order to sustain this essential informational foundation for our technological capability.

Bush went on to point out that the demands of industry and of government did not generally allow the kind of environment best suited to the performance of good basic science—albeit with some notable exceptions. Academic institutions and endowed research institutes, free of commercial immediacy, were proposed as the ideal answer:

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[6] Ibid., pp. 18 and 19.
[7] Ibid., p. 13.
[8] Ibid., p. 14.
[9] Ibid., p. 18.

> Publicly and privately supported colleges and universities and the endowed research institutes must furnish both the new scientific knowledge and the trained research workers. These institutions are uniquely qualified by tradition and by their special characteristics to carry on basic research. They are charged with the responsibility of conserving the knowledge accumulated by the past, imparting that knowledge to students, and contributing new knowledge of all kinds. It is chiefly in these institutions that scientists may work in an atmosphere which is relatively free from the adverse pressure of convention prejudice, or commercial necessity. At their best they provide the scientific worker with a strong sense of solidarity and security, as well as a substantial degree of personal intellectual freedom. All of these factors are of great importance in the development of new knowledge, since much of new knowledge is certain to arouse opposition because of its tendency to challenge current beliefs or practice.
>
> Industry is generally inhibited by preconceived goals, by its own clearly defined standards, and by the constant pressure of commercial necessity. Satisfactory progress in basic science seldom occurs under conditions prevailing in the normal industrial laboratory. There are some notable exceptions, it is true, but even in such cases it is rarely possible to match the universities in respect to the freedom which is so important to scientific discovery.
>
> To serve effectively as the centers of basic research these institutions must be strong and healthy. They must attract our best scientists as teachers and investigators. They must offer research opportunities and sufficient compensation to enable them to compete with industry and government for the cream of scientific talent.[10]

And somewhat later in the discussion:

> Although there are some notable exceptions, most research conducted within governmental laboratories is of an applied nature. This has always been true and is likely to remain so. Hence Government, like industry, is dependent upon the colleges, universities, and research institutes to expand the basic scientific frontiers and to furnish trained scientific investigators.[11]

Although these criticisms of government and industry may seem to have been too strong in light of events subsequent to 1945, the fact remains that academic institutions have come to be the backbone of basic scientific research in this country. And it is no mere coincidence that research and advanced science education go hand in hand. Research is a learning process in itself, and it would be difficult to imagine another arena for the training of future scientists. The research process, that magic art of applying all that one can learn from books and in the classroom to achieve some new understanding of the unknown, is only learned by doing. Although there may be some sort of advisor to lend a helping hand, a senior person to show how some of more obvious pitfalls may be avoided and to offer helpful comments, research is actually taught by letting advanced students work independently on a problem.

This is a slow process, for it demands that important work be done by those who are often the least trained. But it seems to be the best process that has been found, and it explains why research and teaching are interrelated. Wherever good basic research is done, be it in industry, government, university or elsewhere, the training of junior people inevitably appears as an essential part of the endeavor.

This interest in training is hardly an altruistic motive of senior researchers, for they are well aware that the challenging, at times iconoclastic, questioning of young students is an essential stimulus to the creation of new ideas. In the physical and mathematical sciences, major advances are often made by very young scientists, as attested by the surprising number of Nobel awards for work done by people in the early stages of their careers. It is therefore not surprising that scientists are uncommonly aware of the need for good training of students and of the need to encourage bright new talent to enter the field.

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[10] Ibid., p. 19.
[11] Ibid,. p. 20.

Bush and his advisors were particularly sensitive to the depletion of science talent occasioned by World War II. His report naturally recommended training for returning servicemen. But his primary concern was on the need to ensure a continuing and increasing influx of new talent into science. These would have to be students attracted to science careers at an early age, certainly before completion of high school. Therefore, the growth and maintenance of a vital science community would require the development and implementation of better instruction in both high schools and colleges. Quoting again from the report:

> Students drop out of school, college, and graduate school, or do not get that far, for a variety of reasons: they cannot afford to go on; schools and colleges providing courses equal to their capacity are not available locally; business and industry recruit many of the most promising before they have finished the training of which they are capable. These reasons apply with particular force to science: the road is long and expensive; it extends at least 6 years beyond high school; the percentage of science students who can obtain first-rate training in institutions near home is small.
>
> Improvement in the teaching of science is imperative, for students of latent scientific ability are particularly vulnerable to high school teaching which fails to awaken interest or to provide adequate instruction. To enlarge the group of specially qualified men and women it is necessary to increase the number who go to college. This involves improved high school instruction, provision for helping individual talented students to finish high school (primarily the responsibility of the local communities), and opportunities for more capable, promising high school students to go to college. Anything short of this means serious waste of higher education and neglect of human resources.
>
> To encourage and enable a larger number of young men and women of ability to take up science as a career, and in order gradually to reduce the deficit of trained scientific personnel, it is recommended that provision be made for a reasonable number of (a) undergraduate scholarships and graduate fellowships and (b) fellowships for advanced training and fundamental research. The details should be worked out with reference to the interests of the several States and of the universities and colleges; and care should be taken not to impair the freedom of the institutions and individuals concerned.[12]

In summary, the agency which Bush was recommending be created to promote and maintain basic research would necessarily have to be in the science education business as well. Further, it was recognized that the agency's interest might properly have to extend to the precollege level of education.

C. PRECOLLEGE EDUCATIONAL NEEDS AND NSF

Congress recognized the necessity of having scientists be responsible for science and education. The National Science Foundation Acts of 1950[13] stated in Section 3(a) that, "The Foundation is authorized and directed—(1) to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences * * *". Section 3(b) stated, "In exercising the authority and discharging the functions referred to in subsection (a) of this section, it shall be one of the objectives of the Foundation to strengthen basic research and education in the sciences * * *". Education thus became part and parcel of the responsibilities of NSF, as if in approbation of the statement by Dr. James B. Conant, President of Harvard University, that,

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[12] Ibid., p. 26.

[13] Public Law 81-507; 64 Stat. 149.

> * * * in every section of the entire area where the word science may be properly applied, the limiting factor is a human one. We shall have rapid or slow advance in this direction or in that depending on the number of really first class men who are engaged in the work in question * * *. So in the last analysis, the future of science in this country will be determined by our basic educational policy.[14]

A compact of faith concerning the importance of science education had been made. It was only a matter of time before the National Science Foundation was impelled, by its own sense of national interest and, a few years thereafter, by impressive evidence of Russian technological might, into a deep involvement with science education at all levels. The need for proper preparation of students for the study of science at the undergraduate college and university level led to a concern for improved training of high school science teachers and for development of better curricula for the teaching of high school science. But it soon became clear that NSF would have to take responsibility for the creation and maintenance of adequate science instruction at these levels, as well as at the graduate level.

Although the question of whether pre-college science education might better be relegated to the Office of Education has been vigorously debated from the outset, proponents of NSF's pre-college program cite a number of reasons for believing that a good deal would be lost in such a transfer. The Office of Education, very appropriately, is primarily concerned with subjects of central interest to schools of education insofar as teacher training and curriculum development are concerned. These schools are designed to prepare teachers to teach, and they provide unique instruction is a wide range of topics related to the difficult problems teachers encounter and must handle. But they rarely are equipped to provide extensive education in specific subjects: teachers generally study history, science, economics and other such fields outside of schools of education, for the reason that it is generally agreed that this material is best handled by experts who are either directly involved in research or who are associated with research environments.

Why, then does the NSF pre-college education effort appear to some as inappropriate? Perhaps it is because science—particularly mathematics but increasingly some physics and chemistry—and social studies are generally agreed to be an important part of the curriculum at the elementary level. This has necessarily propelled NSF into elementary education, an area that would appear to be far from its research mission.

But is NSF involvement truly necessary? Proponents claim that it is, for this is the point at which important conceptual impressions are formed. They point out that science is an abstract art, built upon concepts that require careful presentation in order to be understood. The material must be well illustrated with elaborate care, and often the student must be able to observe, or participate in, an experiment before a clear understanding is obtained. But in order to begin to understand the processes of science, the student must at least learn a bit about how to observe events, and then how to think about how those specific events illustrate some general law of behavior. And this is just the start of what needs to be mastered.

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[14] As quoted in: Krieghbaum, Hillier and Rawson, Hugh. An investment in knowledge. New York, New York University Press [1969] p. 84.

The problem of adequately presenting abstract concepts, and of involving students in classroom experiments, needed to be overcome if United States science education was to be improved. This in turn required new curricula and extensive science instruction for teachers. NSF provided the institutional mechanisms and the support for this to be done. The research community, primarily from universities, responded by providing senior people with the necessary talent and experience in science teaching. Significant improvements in pre-college science teaching might well not have been obtained without this direct involvement of the science community.

Thus it would seem reasonable to question whether any other agency had the sort of relationship with the scientific community that was needed to bring such a program into being, or to maintain such an effort once it was established. In the words of Congressman Tom Railsback (R. Ill.), NSF.

> ". . . has torn down old barriers to communication between those who teach in the classroom and those who do research at the forefront of our quest for scientific understanding." [15]

In their critical review of the NSF pre-college education program, Kreighbaum and Rawson [16] mention the impact of the NSF training institutes for teachers as follows:

> In the long view of history, possibly the greatest contribution will be that the NSF institutes in general, and the Summer Institutes in particular, helped to focus an evolving philosophy of teacher training on a key idea: That subject-matter courses should receive essential emphasis. The "workshop" idea that centered around how-to courses has been supplanted by subject-oriented work, such as that given in institutes. This key idea has been adopted not only for other educational areas in the United States but by foreign countries. And while this educational reorientation was taking place, the institutes programs also played a quiet role in helping to integrate some Southern colleges and universities.
>
> While the NSF institutes programs may not be the perfect or even the final answer, they appeared to be the best solution yet devised to achieve large scale improvements in teaching of science and mathematics in United States schools, a goal desired by nearly all Americans.

They go on to say:

> In the final analysis, two things seemed clear: The institutes had become embedded in the nation's educational system and, although it was difficult to describe with scientific precision the effects of these training programs, they were contributing to better science and mathematics instruction in the United States. But beyond this, it also was apparent that the ultimate prerequisite for better teaching was adequate preservice training of science and mathematics teachers, whether by NSF, other Federal agencies, the states, local communities, or private institutions.[17]

As stated earlier, pre-service training is the area in which the Office of Education is felt to have primary responsibility, so that NSF probably would not be expected to get involved. Although there might appear to be a possible demand to develop special courses for teachers as formal offerings of science departments in universities and colleges, science faculty have voiced strong objection to doing so in the past.

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[15] U.S. Congress. House. Subcommittee of the Committee on Appropriations. HUD-Space-Science-Veterans appropriation for 1976. Hearings, 94th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1975, part 6, p. 680.

[16] Krieghbaum, Hillier and Rawson, Hugh. An investment in knowledge. New York, New York University Press [1964] p. 333.

[17] Ibid., p. 334.

The special science education programs sponsored by NSF for pre-college teachers are tailored to special needs and are not felt to be generally appropriate for other students of science. This is a major factor in the popularity of the institutes to college and university science faculty, for the institutes clearly have a special function that is not likely to be confused with advanced education in the sciences. The focus is on the curricula and methods to be used by teachers, rather than upon the teaching of standard science courses.

D. PROBLEMS AND OBJECTIONS

In spite of its substantial contributions to science teaching, and its tremendous popularity with teachers, the NSF pre-college education program has often lacked support from some of those who are responsible for it. The National Science Board has on occasion (see Chapter IV) evidenced concern that the high school education programs at NSF might overshadow the "more important" mission of the sponsorship of basic research. In 1956 the Board resisted the decision of the House Committee on Appropriations to increase, by about 2½ times, NFS's requested budget for high school science teacher training for Fiscal Year 1957. This was shortly after the time when the reports had been released showing superior science training in the USSR.

More recently, the Office of Management and Budget is reported to feel that pre-college education belongs in the Office of Education. This is not entirely a new suggestion, nor are the arguments for and against such a transfer, as evidenced by Krieghbaum and Rawson:

> Ever since the NDEA was passed in 1958 there has been speculation that management of the NSF institutes eventually would be transferred to the Office of Education. Such a consolidation might well create complications for the training programs in science and mathematics. Most institute directors, for example, undoubtedly would prefer to deal with NSF, which is part of the "scientific establishment," than with the Office of Education, which in many quarters is viewed as a stronghold of "educators." Some observers doubted the Office of Education would get the same amount of cooperation from the "scientists" as NSF has received. And there was the simple fact that the science and mathematics institutes appeared to be running smoothly under NSF's suzerainty.[18]

The OMB interest in transfer to HEW is said to be based on a feeling that greater efficiency would derive from having all pre-college education programs at one place. Since the participation of scientists seems to be an important factor in the success of the program, there is reason to question whether the NSF institutes programs would be able to be effectively maintained at HEW. Although the influence of OMB on the NSF budgets for education is not well-documented in available literature, conversations with NSF staff make frequent reference to OMB's position and opinions along this line.

Another reputed policy of OMB is to avoid programs which might become sources of continuing Federal support to education. This is said to apply to the Department of Health, Education and Welfare as well as to the National Science Foundation. The repeated reorganizations and relabelings of the NSF education programs, starting in fiscal year 1968, are said to be the result of OMB's insistence that programs not be of a continuing nature.

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[18] Ibid., p. 331.

Whether or not these reports have substance, even in part, it would seem that the NSF education efforts are now conducted somewhat on a "project-by-project" basis with at least the appearance that programs terminate after some particualr objective has been acheived. This creates a kaleidoscopic series of program titles that are often confusing.

The Congress, on the other hand, seems to be of the opinion that the NSF pre-college education programs have been very effective and are one of the most attractive features of the entire NSF operation. As documented later in this discussion, Congress has frequently mandated a minimum spending level for these programs and has occasionally increased the budgets for the programs above Administration budget requests.

In summary, the NSF pre-college education effort exists amid counter pressures from the Congress, from the OMB, and from the National Science Board. The interest of Congress has served to maintain these programs within NSF, while the continuing questions of the National Science Board about the appropriateness of NSF involvement at this level of education and the presumed pressure from OMB have demanded that the NSF staff and their grantees seek ways to improve the effort and make it an acceptable part of NSF. This would account in part for the many changes in program objective, in program structure, and in program title that have occurred from year to year. Later chapters will detail these changes, and relate how the NSF involvement in pre-college curriculum development and implementation led to serious congressional concern in 1975.

II. DEVELOPING IMPERATIVES FOR A NATIONAL PROGRAM IN SCIENCE EDUCATION

A. THE EARLY PERIOD: 1950–1955

To those who studied the problem of how to apply science to the national benefit at the close of World War II, it was apparently clear that science education must be an essential part of any national science effort. There seems to have been no question about the matter in the mind of President Roosevelt at the time when he asked Vannevar Bush to outline a national policy for science, for the fourth of his requested recommendations was to deal with the question:

> Can an effective program be proposed for discovering and developing scientific talent in American youth so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war?[19]

In that same letter, President Roosevelt underlined his expectations for the utility of science with the following:

> New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life.

In his response, "Science—The Endless Frontier",[20] Dr. Bush began his discussion on education by saying:

> The responsibility for the creation of new scientific knowledge rests on that small body of men and women who understand the fundamental laws of nature and are skilled in the techniques of scientific research. While there will always be the rare individual who will rise to the top without benefit of formal education and training, he is the exception and even he might make a more notable contribution if he had the benefit of the best education we have to offer. I cannot improve on President Conant's statement that:
>
> "* * * in every section of the entire area where the word science may properly be applied, the limiting factor is a human one. We shall have rapid or slow advance in this direction or in that depending on the number of really first-class men who are engaged in the work in question. * * * So in the last analysis, the future of science in this country will be determined by our basic educational policy."[21]

However, there was no realization at that time of the massive effort that would be recognized as needed about ten years later to overhaul the nation's pre-college educational programs.

As the concept of the National Science Foundation began to emerge and finally became reality through the National Science Foundation Act of 1950, it seemed to be generally assumed that Foundation activities would be limited to the college and graduate levels. The wording of the Act reflected this feeling by specifying that the Foundation was authorized to award scholarships and graduate fellowships to implement its responsibility for education in the sciences:

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[19] Letter from President Franklin Delano Roosevelt to Vannevar Bush, Director, Office of Scientific Research and Development, dated November 17, 1944.

[20] Op. cit.

[21] Ibid., p. 23.

FUNCTIONS OF THE FOUNDATION

SEC. 3. (a) The foundation is authorized and directed—

(1) to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences;

(2) to initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences, by making contracts of other arrangements (including grants, loans, and other forms of assistance) for the conduct of such basic scientific research and to appraise the impact of research upon industrial development and upon the general welfare;

(3) at the request of the Secretary of Defense, to initiate and support specific scientific research activities in connection with matters relating to the national defense by making contracts or other arrangements (including grants, loans, and other forms of assistance) for the conduct of such scientific research;

(4) to award, as provided in section 10, scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering, and other sciences;

(5) to foster the interchange of scientific information among scientists in the United States and foreign countries;

(6) to evaluate scientific research programs undertaken by agencies of the Federal Government, and to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups;

(7) to establish such special commissions as the Board may from time to time deem necessary for the purposes of this Act; and

(8) to maintain a register of scientific and technical personnel and in other ways provide a central clearinghouse for information covering all scientific and technical personnel in the United States, including its Territories and possessions.

(b) In exercising the authority and discharging the functions referred to in subsection (a) of this section, it shall be one of the objectives of the Foundation to strengthen basic research and education in the sciences, including independent research by individuals, throughout the United States, including its Territories and possessions, and to avoid undue concentration of such research and education.

(c) The Foundation shall render an annual report to the President for submission on or before the 15th day of January of each year to the Congress, summarizing the activities of the Foundation and making such recommendations as it may deem appropriate. Such report shall include (1) minority views and recommendations if any, of members of the Board, and (2) information as to the acquisition and disposition by the Foundation of any patents and patent rights.[22]

Section 10 of the act specified the nature of these scholarships and fellowships:

SCHOLARSHIPS AND GRADUATE FELLOWSHIPS

SEC. 10. The Foundation is authorized to award, within the limits of funds made available specifically for such purpose pursuant to section 16, scholarships and graduate fellowships for scientific study or scientific work in the mathematical, physical, medical, biological, engineering, and other sciences at accredited nonprofit American or nonprofit foreign institutions of higher education, selected by the recipient of such aid, for stated periods of time. Persons shall be selected for such scholarships and fellowships from among citizens of the United States, and such selections shall be made solely on the basis of ability; but in any case in which two or more applicants for scholarships or fellowships, as the case may be, are deemed by the Foundation to be possessed of substantially equal ability and there are not sufficient scholarships, or fellowships, as the case may be, available to grant one to each of such applicants, the available scholarship or scholarships or fellowship or fellowships shall be awarded to the applicants in such manner as will tend to result in a wide distribution of scholarships and fellowships among the States, Territories, possessions, and the District of Columbia.[23]

It was from this beginning that the NSF education effort began to evolve, to broaden, and eventually to attempt to reach students at the very earliest stages of education as a result of a growing feeling that the study of science at every level must be built on an adequate base of knowledge at the preceding level. Finally in 1972, some 22 years after the establishment of the Foundation, Congress gave specific recognition to the nature of this effort by amending the Act of 1950 through Public Law 92-372, 86 Stat. 526 which added the important phrase "at all levels" to the wording of Section 3.(a)(1), so that it now reads:

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[22] The National Science Foundation Act of 1950 (Public Law 81-507, 64 Stat. 149) (May be found in the Conference Report—H. Rept. No. 1958—reprinted in the Congressional Record, v. 96, April 27, 1950, p. 5899 ff.).

[23] Ibid.

> SEC. 3. (a) The Foundation is authorized and directed—
>
> (1) to initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs at all levels in the mathematical, physical, medical, biological, engineering, social, and other sciences, by making contracts or other arrangements (including grants, loans, and other forms of assistance) to support such scientific and educational activities and to appraise the impact of research upon industrial development and upon the general welfare.[24]

This reflects the Foundation's deep involvement with science education at levels that might seem remote from its responsibilities for research and for the education, presumably the advanced education, of scientists. It also raises some fundamental questions about whether NSF has made an unwarranted invasion into the proper territory of the Office of Education, and whether the Foundation or any office of the Federal Government, should assume the sort of continuing responsibility for pre-college education that may be needed.

Pre-college education is generally considered to be a community-county-state responsibility, under the direction of primarily local interests. Even with the limitations implied by the term "science", great care must be exercised in order to avoid upsetting longstanding relationships that exist between the Federal Government and the local institutions that manage and support the schools.

In addition, it must be recognized that NSF's educational activities in such fields as the life and social sciences have the potential to be offensive to the opinions of individuals, of groups, or of communities. And so, while the maintenance of a strong science effort in this country would seem to be properly a national issue, and while it follows that the training of scientists is properly a matter for national concern, there seem to be very definite problems in trying to establish the sort of pre-college educational system which will enable students from every locality of the country to get the training they need to be prepared for the study of science at the college or university level.

A1. The Education Programs Begin

Although the National Science Foundation never chose to implement its authority to award scholarships, primarily because it could not establish that a lack of college tuition support was keeping prospective students from further study, it established the graduate fellowships program, which persists in essential form to the present time, soon after it began operations. These fellowship awards are provided on the basis of demonstrated academic achievement and ability, and allow recipients to attend the institutions of their own choice.

In Fiscal year 1952, the Foundation made its first fellowship awards to 624 students at the graduate level and 55 at the post doctoral level. This was the totality of the NSF education effort in that year, except for a small ($7,200) investment to initiate a totally different type of program aimed at improving the competence of teachers at the college level. Entitled "Research Education in the Sciences," this latter program was intended to provide support for college teachers to spend either a summer or a full year, on leave, at institutions where they could perform actual research. This effort to improve teacher competence was a new direction, but was designed to meet a need that appeared urgent in terms of the Foundation's responsibility.

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[24] Functions of the Foundation (42 U.S.C. § 1862).

The first Annual Report of the Foundation had reflected a growing awareness in the business community of a shortage of scientists and engineers. To quote:

> Robert E. Wilson, Chairman of the Board, Standard Oil Co. (Indiana) and Chairman of the Research Committee of the National Association of Manufacturers, is one of many industrial leaders who have called attention to the present critical shortage in trained scientists and engineers. Mr. Wilson adds that "this shortage is certain to grow more serious over the next few years and to seriously hamper our war effort."
>
> Lawrence P. Lessing writing in *Fortune* carries the thought further: "Billions may be poured into mere brawn and steel, or into mere applied research on weapons, but unless these are animated by a rising stream of basic science and technical brains they will come to nothing."
>
> In closing his article Lessing quotes an editorial from *Chemical and Engineering News:* "The fast approaching bottleneck of too few scientists and technologists can well be the most efficient weapon possessed by Stalin and the Politburo."
>
> Since the training of young scientists is of such crucial importance, the National Science Foundation has determined that a graduate fellowship program should be the first order of business. First emphasis will be given to fellowships rather than scholarships, because the completion of graduate work will have the most immediate effects upon the national supply of trained manpower.[25]

However, there clearly needed to be some way to stimulate more students into going to college and to provide the best possible training for those who did go to college. A survey by the National Research Council's Office of Scientific Personnel had shown that 46 percent of the students receiving doctorates in science in the period from 1936 to 1945 had received their undergraduate training at institutions which did not (at the time the student was in residence) offer science doctorate degrees. In other words, the faculty in those institutions, many of which were small colleges, were isolated from the information and the stimulus to be obtained from a direct personal involvement in the performance of science.

Thus the concept of research education for teachers appeared to be very important to NSF as a means of increasing teaching performance in science at the college level. Discussing the matter in its Second Annual Report, the Foundation stated:

> If a teacher is to inspire and stimulate his students with the desire to pursue research careers, it seems clear that he himself must appreciate research. He must be aware of significant developments in his field and be able to communicate to his students the excitement and interest in new developments as they occur. This in turn means that he must keep in touch with research progress and enjoy at intervals a chance to do research or to form fresh associations with other research scientists, preferably away from his home campus. The Foundation is, therefore, assisting in developing methods for increasing the effectiveness of teaching at institutions of higher learning and increasing the quality of training in the sciences.[26]

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[25] The First annual report of the National Science Foundation, 1950-51. Washington, U.S. Govt. Print. Off., [1952] p. 17.

[26] The Second annual report of the National Science Foundation, fiscal year 1952. Washington, U.S. Govt. Print. Off., [1953] p. 29.

This was the beginning of what would later become a major effort to improve teacher competency at all levels. Although directed at the college level, it marked the first direct attempt by NSF to magnify its educational investment by training those who teach, as opposed to such alternative uses of funds as scholarships support for students who might not otherwise go to college.

The matter was approached with the degree of caution that has since become a characteristic of the Foundation. In its appropriation request for Fiscal Year 1953, the Foundation included $100,000 for a pilot program in research education in the sciences, of which almost $41,000 was eventually obligated out of an appropriated amount of $50,000 (see Appendix A).

This was to be a trial, and as such it was subject to a good deal of revision. Although the research education theme of this early program has reappeared again and again among NSF education programs at the college levels, in these early years it was rapidly replaced by a new and more generally applicable idea for college teacher training in science.

This change in direction reflected a good deal of previous study by the Foundation, which had begun an examination of alternative approaches to college teacher education. As early as the fall of 1951, Dr. Harry C. Kelley, the Foundation's Assistant Director for Scientific Personnel and Education, made contact with Dr. Russel Cooper, executive director of the Program for College Teachers at the University of Minnesota. This Minnesota program consisted of an academic year-long workshop for recipients of Ford Foundation fellowships. Through Cooper, Kelly met Dr. J. W. Buchta, chairman of the Physics Department at the University of Minnesota, and a member of the advisory committee for Cooper's program. Asked for suggestions, Buchta outlined three types of effort which he felt deserved consideration:

(1) Summer programs of 5 to 7 week duration for faculty of small colleges to convey recent research results in various fields of interest;

(2) A special fellowship reward for teachers who had proven their excellence by inspiring relatively large numbers of students to go on to graduate school; and,

(3) Summer institutes for high school science teachers.

The third suggestion seemed particularly important to Buchta, who pointed out in a letter of November 28, 1951, that:

> When the high school science teacher returns to college during a summer session, he often finds that he is excluded from the graduate courses in science because he does not have the stated prerequisites. As a result, we find many of the more able and ambitious teachers—those who return for additional college work—are diverted to professional courses and degrees in education—often administrative phases. There is need for summer programs explicitly designed for the high school science teacher. For many young people, the time of decisions regarding their careers is the high school period. The high school teacher is an important factor in education of future scientists.[27]

Manpower projections began to be gloomy in 1953, indicating that the number of science and engineering graduates from universities and colleges in 1954 would be only 38 percent of the number produced in 1950. It was also estimated that in 1955 the USSR would produce

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[27] Krieghbaum & Rawson, op. cit., p. 91.

50,000 engineers, as opposed to 17,000 for that year in the United States.[28] As a result, the Foundation apparently began to look for new formats for college science teacher education that would not require the amount of close supervision of research training and that would permit greater numbers of college teachers to participate. Dr. Waterman's concern, as Director of the NSF, was clearly evident in his testimony for the fiscal year 1954 NSF budget before the House Committee on Appropriations.[29]

Since the research education had been clearly labeled as experimental in nature, and possibly because the Foundation did not have a line-item budget, the Foundation was apparently able to change its fiscal year 1953 program considerably. It would seem that this occurred after the House appropriation hearings for fiscal year 1954 had been held, for no mention was made of this change in plan during those proceedings, although the research education program was specifically discussed. But whatever negotiations were held with the appropriate congressional committees, in fiscal year 1953 the Foundation sponsored four summer institutes of the type that had been suggested by Dr. Buchta (perhaps in addition to some reduced support for research education). These were the following:

1. Colloquium on College Physics, State University of Iowa, June 17–20, 1953.
2. Conference on College Mathematics, University of Colorado, June 15 through August 8, 1953.
3. Conference on College Biology, University of Oklahoma, June 15–19, 1953.
4. Institute for College Teachers of Physics, University of Minnesota, June 15 to July 18, 1953.

Their description in the Third Annual Report of the National Science Foundation made it clear that the State University of Iowa had had a long history in helping to improve the competency of college teachers, so that Minnesota had hardly been unique in its program:

> The 4 institutes were attended by a total of 250 teachers from small colleges. The participants came largely from the surrounding regional areas, although in the case of the mathematics conference at the University of Colorado all sections of the country were represented.
>
> The Colloquium on College Physics, an annual event now in its 15th year was developed by G. W. Stewart, head of the Physics Department (retired), State University of Iowa. The Colloquium consisted of a series of lectures by leading scientists, followed by discussion periods. A feature of the program was the exhibition of experimental teaching devices created by members of the Colloquium.
>
> The purpose and organization of the Conference on College Biology at the University of Oklahoma were similar. Lectures were given throughout the week by specialists in several fields of modern biology, followed by audience participation and discussion.
>
> The Conference on Collegiate Mathematics at the University of Colorado and the Institute for College Teachers of Physics at the University of Minnesota were of longer duration. At Colorado lectures were given daily throughout the conference by two outstanding mathematicians. These were supplemented by lectures from a series of visiting scientists who covered special phases of modern mathematics. A feature of this institute was the spontaneous organization, by members of the conference, of an informal group for discussion of problems of mutual interest, including curricula, methods of teaching, and new textbooks.[30]

But in fact, the entire summer institute concept seems to have been developed and pioneered by the General Electric Company, which had established an imaginative program of summer institutes for high school teachers in 1945. The success of these was eventually to impel the National Science Foundation into a very similar effort. Although created by GE, the idea spread to other corporations and eventually to NSF.

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[28] U.S. Congress. House. Committee on Appropriations. Hearings before a Subcommittee of the Committee on Appropriations. Independent offices appropriations for 1954. Hearings. 83rd Congress, 1st session. Washington, U.S. Govt. Print. Off., 1953. p. 60.

[29] Ibid., p. 60.

[30] Third annual report of the National Science Foundation, Washington, U.S. Govt. Print. Off., [1954]. p. 53.

In late summer of 1944, the outcome and close of World War II seemed sufficiently assured that GE corporate planners were beginning to think about the transition to a peacetime economy. One matter for attention would clearly be the post-war recruitment of high quality engineering talent at GE, for such a high technology firm would clearly need to replenish its technical staff after such a long hiatus.

In the course of studying the problem, GE officials acquired records on public and parochial school science and mathematics teachers from the New York State Department of Education. These indicated a tremendous need for teacher retraining in science and mathematics to provide adequate education for those who would later undertake undergraduate university and college study in technical fields.

General Electric officials in Schenectedy, New York, particularly Maynard Boring, who was responsible for recruiting technical and scientific talent, and Roy C. Muir, GE vice president for engineering initiated discussions about the problem with Union College faculty and officials. A Union College science faculty member described the objectives of General Electric's interest to Dr. Dixon Ryan Fox, the College's president, as follows:

> (a) To improve, through a long range program, the teaching of science in the high schools of the coutry.
>
> (b) To bring the General Electric Company to the attention of students in the high schools of the country.
>
> (c) To encourage the bringing of exceptional high school students to the attention of the General Electric Company.
>
> Of these, the first is the prime objective and it is to this end that the matter has been brought to the attention of Union College with the request that we present as full a plan as is now feasible.[31]

The final plan presented by Dr. Fox to General Electric officials was sufficiently rigorous to be justified as graduate level instruction, and was designed for those having a significant background in college-level science. As might be expected, the general format would be an intensive course of study in the summer for a small number of participants—hopefully one from each State as first conceived, though it was later modified to be forty in number with no geographic restrictions. As proposed by Dr. Fox:

> The summer session shall extend to six weeks, and classes should be conducted on five days each week. It can proceed, if desired, after July 1, 1945. The attendance shall be limited to those nominated by the Company, and those so registered shall be known as *Fellows*. It is expected that all will have taken the bachelor's degree. It is further presumed that all shall have had at least two substantial college courses in Physics. They will find the work difficult if they are not familiar with the calculus and with differential equations. Graduate credit shall be given to those who do satisfactory work, to the extent of nine points or semester hours, representing more than one quarter-year's accomplishment, validated by the College, and presumably to be accepted by other institutions as toward the Master's or Doctor's degree. It is understood that an important part of the Fellow's educational experience will come in his or her contacts with the staff of the General Electric Company within the Company's buildings. As a matter of fact the Fellow will acquire more from six weeks' study under these conditions than would be possible during the same time in nearly any university, but since

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[31] Krieghbaum and Rawson, ibid., p. 66.

> time and credit are associated in the judgments of university committees nine points credit is all that can be feasibly allowed.
>
> Each Fellow would be expected to take two courses. We are ready to offer two courses in Physics, and, if desired, one course in Chemistry. Work of this grade and character must be given in class sections limited to twenty students. Some laboratory work will be given (in sections of ten), but it is not expected that a large amount of laboratory work will be required.
>
> It is impossible to estimate the needs of every student, or even at the present time to be sure of exactly what would best suit the majority. Some modifications of plan might be necessary at the last moment.[32]

The focus on courses which would qualify for graduate credit was indicative of the sort of misunderstanding or uneasiness that university faculty had about special courses for high school teachers. Academic standards lie at the very heart of the problem of maintaining quality in advanced education: and it is the departmental faculty themselves who guard these standards most forcefully, for they know that their individual futures can depend upon outside opinions of the quality of a department's collective teaching efforts. One of NSF's later achievements was to provide a format which separated appropriate teacher-training courses from the standard science curricula of academic college and university departments, so that content and standards could be adjusted to the real needs of those in the program. But this was a lesson that was yet to be learned. The four courses proposed for initial GE program were ambitious in terms of the general training of high school science and mathematics teachers:

> (1) "Modern Physical Theory"—an advanced lecture course on radiation and matter or on quantum theory.
>
> (2) "Electronics."
>
> (3) "Topics in New World Physics"—described by Fox as, ". . . interesting, suggestive and primarily informative, taking up for more than casual treatment such topics as radar, cyclotron, betatron, nonlinearity, servomechanisms, etc."
>
> (4) "Experimental Technique"—which was to instruct in glass blowing, vacuum technique, instrumentation, and other laboratory problems.[33]

Three of these were approved by the General Electric Education Committee, and were offered on the following bases:

> Electronics (Vacuum Tubes—Theory and Phenomena). 4 lectures and 2 laboratory periods weekly. 3 semester hours credit.
>
> Modern Physical Theory and Phenomena. 32 lectures (with problem assignments). 3 semester hours credit.
>
> Modern Applications of Physical Measurements. Lectures, conferences and demonstrations (with problem assignments). 2 afternoons each week. 2 semester hours credit.

Although the problem of finding the proper level and scope for the courses required a great deal of attention and adjustment, the General Electric Science Fellowships were a considerable success. Over the years, the program was expanded and came to involve four different academic institutions in science instruction and three others in mathematics. But later on, as the National Science Foundation programs began to grow large in the late 1950's, General Electric decided to direct its educational efforts to other fields, such as guidance counseling for humanities teachers, where its efforts might have a more unique impact. In 1959 General Electric terminated its pioneering effort at the close of the fifteenth summer session for GE Science Fellows. By that time, approximately 2500 public, private, and parochial school teachers had received additional training under the program, at a total reported cost of about $1,500,000 to General Electric.

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[32] Ibid., p. 67.
[33] Ibid., p. 68.

Following the initiation of the General Electric program, the Westinghouse Educational Foundation established an effort with the similar intent of improving the capabilities of science teachers. This was done in response to a proposal from the Massachusetts Institute of Technology, which proposed a six-week summer program, to include:

(1) Daily lectures on science by certain MIT faculty closely connected with the teaching of physics, chemistry and mathematics to freshmen and sophomores;

(2) Daily lectures on recent developments in physics, chemistry, biology, meteorology, geology, and aeronautical engineering;

(3) Inspection trips to MIT science facilities; and

(4) Informal conferences on the subject of science teaching.

The program formally opened in 1949, only to encounter the same course-content problems as did the GE program. Even after some years of operation, an MIT representative reported to Westinghouse as follows:

> From beginning to end the course is concerned with the subject matter of science. The science teachers would prefer that the science they learn be directly related to the science they must teach in secondary school. In addition they feel that the laboratory experiments should be readily adaptable to their own school environment. No attempt, however, has been made to limit the teaching or the laboratory along lines which would better suit the student. The student is disappointed by the fact that nowhere in the course is he told how to teach science at the secondary school level * * * [34]

Clearly, there was a need for teacher training programs, but apparently the need was not for the type of science and mathematics instruction that college and university faculty initially wanted to provide. But given a bit of financial help, the high school teachers kept applying to attend these programs and they were expanded by Westinghouse.

Other corporations entered the field as well, including E. I. DuPont de Nemours and Co., Shell Companies Foundation, Crown Zellerback Foundation, and the Burroughs Adding Machine Co. In addition, a few universities offered special subject-oriented summer programs without outside sponsorship. However, the lack of assistance for travel, tuition, and living expenses seems to have been a barrier to poorly paid teachers, and those programs were not nearly as successful as the programs under industrial sponsorship which could offer partial support for expenses.

Thus it seems that at the time of the creation of NSF in 1950, the stage was set and the problem defined. Businessmen in high technology industries, which were dependent upon a continuing supply of well-trained scientists and engineers, had identified high school education as the weak link in the educational system. On the basis of extensive examination, apparently fairly well-documented by data, they had come to feel that poor high school science and mathematics teaching not only resulted in inadequate preparation for later study, but it also tended to discourage students from becoming interested in science, engineering, and mathematics. This discouragement would deter some students from making the effort to go to college, and would deter many who would go to college from careers in science and engineering.

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[34] Ibid., p. 79.

While these industrial programs may have been partly justified as long range personnel recruitment (it stood to reason that a teacher who became impressed with a company through his or her summer experience would communicate his or her enthusiasm to students), and though they certainly were good advertising, they were still very serious efforts predicated on an understanding of the potentially serious national consequences of poor science education at the high school level.

Of course, these industrial efforts could not hope to meet the magnitude of the need that existed, but they did show a good deal about how the problem could be met and they did serve to acquaint educators, at both the college university level and at the high school level, with the fact that such a need truly existed.

Under these circumstances it was almost predictable that, as soon as it began to be actively involved in science education, NSF would be propelled into active involvement at the high school level.

Perhaps it should be a testament to the isolation of scientists involved in graduate education and research in 1950—those who would run the education programs at NSF—that they would appear to have been unaware of these events. Or perhaps it was merely the result of the fact that so many United States scientists had been involved in urgent wartime work and were, in 1950, putting all of their attention toward reconstructing graduate science programs. Since the high school problem was extensively mentioned in "Science—the Endless Frontier," it is interesting to contemplate the reasons for the absence of attention to this matter in records of discussions relating to the creation of the National Science Foundation and in its early congressional hearings and reports.

Suffice it to say that the Foundation seems to have been genuinely reluctant to become involved in science and mathematics education at the high school level. It was only after it became obvious that college enrollments in science were rapidly dropping that the Foundation came to conclude that its responsibility to improve the nation's capabilities in research demanded a sizeable investment of effort to attract high school students toward science and to properly prepare them to continue the study of science in colleges and universities.

The awakening began to be evident in the Third Annual Report of the NSF, which recounted activities of fiscal year 1953:

> If the Nation's scientific and technical manpower is to be maintained in adequate numbers and proficiency, there must be an adequate flow of students with aptitudes in these fields up through the secondary schools and colleges. The Commission on Human Resources and Advanced Training has analyzed the intelligence distribution of high school and college graduates in order to determine the fraction of the student population capable of completing advanced training.
>
> The findings indicate that 89 percent of our young people having at least the average intelligence of college graduates finish high school in the United States. Of these 38 percent enter college, and 25 percent graduate from college. These figures make clear that a large loss of potential college graduates occurs between high school and college, and that a second substantial loss occurs during the college years.
>
> In the same study estimates were made of the number of bachelor's degrees and doctor's degrees awarded for the 5-year period 1948–52 and for the estimated period 1953–57. For the earlier period the total number of individuals receiving bachelor's degrees in science, engineering, and agriculture totaled about 95,000 per year. The comparable estimate for 1953–57 is 66,800 per year a decline of nearly 30 percent. For the earlier period the number of doctor's degrees granted in the same fields averaged about 4,660 per year, compared with an estimated

> 5,420 per year for the period 1953–57. Since a 3- to 4-year lag exists the decline in doctorate awards will not appear for several years, but after 1956 the number of doctor's degrees awarded will reflect the same downward trend noted above for bachelor's degrees. This is further shown by statistics indicating that the total graduate enrollment at the first year level in all fields of science dropped from approximately 12,000 in 1951–52 to approximately 8,000 in 1952–53.
>
> Interpretation of the figures is complicated by a number of factors, which prevent easy generalization. The decline in the number of graduates in science and engineering is in part due to the effects of the reduced birthrate in the United States during the 1930's. It also coincides with the termination of large-scale Federal support for education under the GI bill.
>
> These factors may explain the situation but the statistics themselves indicate that inadequate numbers of capable young persons are receiving advanced training in the sciences. They raise two questions: (1) how can the total college population, and hence the number of students majoring in science, be increased; and (2) how can the total number of graduate students in all fields of science be increased.[35]

In response, the Foundation considered the possibility of some sort of financial assistance to students at the college level, but dismissed the idea on the grounds that finances did not seem to be the most important limiting factor: the time had not yet arrived when a college education was generally regarded as essential for almost all who were capable. But it did seem to NSF that something had to be done to improve undergraduate teaching in science, which led to the first four summer institutes mentioned above. And the need for something at the high school level was also apparent, though NSF's reluctance to get deeply involved was evident in the description of activities for fiscal year 1953:

> The need for effective science teaching at the secondary school level is also acute since it is at the high school age that many students begin to show an interest in careers in science. It is hoped that ways and means can be found through the science teachers at the secondary school level to identify and motivate toward science those students who should become scientists.
>
> During the past year a grant from the Foundation was awarded to Science Service, Inc. for the support of Science Clubs of America. This aid has strengthened materially the programs of the science clubs and science fairs during the year. In 14 new areas local science fairs were held and their finalists were able to participate in the Fourth National Science Fair held at Oak Ridge, Tenn., in May 1953. In all the Fourth National Science Fair had exhibitors from 29 local fairs. During the coming year the grant will assist in promoting science fairs in about 29 additional localities. Part of the grant was used to finance the compilation and publication of a booklet, *Thousands of Science Projects*, prepared to give students and teachers ideas for science projects that can be undertaken. It is estimated that activities under the grant benefited over 300,000 members of Science Clubs of America.[36]

In the background, Dr. Buchta continued to promote his plan for summer institutes for high school science teachers. Surely he was to be taken seriously, for he had been chairman of the University of Minnesota Physics Department since 1938; had been assistant dean of the College of Science, Literature and the Arts at that institution since 1945; was currently editor of the prestigious Reviews of Modern Physics; had been assistant editor of the Physical Review, the principal United States journal in physics, for 16 years; in addition to holding a number of other high offices.

Dr. Kelly welcomed his interest in the Foundation's education programs, and responded warmly when Buchta submitted a proposal to hold a summer institute in physics for high school science teachers in 1952. However, the NSF reaction turned negative when Dr. Edwin B. Fred, vice chairman of the National Science Board, telephoned Dr. Kelly to say that, although he had initially thought the idea a good one, his conversations with the faculty of the Education Department at his institution (University of Wisconsin) had indicated that (1) such an institute should survey all fields that high school science teachers are normally asked to teach (biology, physics, mathematics, and so forth) so as to fairly treat all subjects and (2) other sections of the country might benefit more from such an institute than Minnesota.[37]

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[35] The Third Annual Report of the National Science Foundation. Washington, U.S. Govt. Print. Off. [1954] p. 51 and ff.

[36] Ibid., p. 54.

In consequence of these statements from a senior member of the National Science Board, Kelly decided not to submit Buchta's proposal to the Board for approval.

Buchta did not give up on his idea. He submitted two proposals for summer institutes in physics to be held at Minnesota in 1953. One of these would be for college teachers and the other for high school science teachers. They would operate simultaneously so the students might benefit from cross-stimulation, but would have different curricula.

NSF funded the proposal for an institute for college teachers, but declined once again to support an institute for high school teachers. Not to be daunted, Dr. Buchta managed to obtain support for this second proposal from the Fund for the Advancement of Education, an independent philanthropy started by the Ford Foundation. The eventual success of this institute made a considerable impression on the NSF staff.

At the same time, complaints from university faculty members about the state of high school science education were increasing in frequency. Dr. Bowen Dees, who was then head of the NSF Fellowships Section, later reported that his conversations at that time with college and university faculty on other subjects seemed inevitably to turn to the inadequacies of high school teaching.

Buchta's proposal was by no means the only attempt to get NSF to support activities to help pre-college teachers or to identify and counsel promising high school students. A variety of other requests were made, to all intents unsolicated in spite of any conversations that may have occurred with NSF personnel.

Through Fiscal Years 1952 and 1953, NSF apparently maintained the official position that, while it was interested in the problems of pre-college instruction, the limitations on its funds would not allow taking on what appeared to be a new and enormous burden in dealing with high schools. Such a position could readily be justified, not only by the size of the NSF budget at that time but also by a legislated limitation of $15,000,000 on the total amount able to be appropriated to NSF in any single year.

The removal of this limitation by the Congress in August 1953 may have been the psychological turning point, for it created the prospect of building a program that would be meaningful without necessarily diverting funds from other programs in research and education at the graduate level, areas which the Foundation regarded as primary. The effect was surely hypothetical, though, for the entire fiscal year 1953 NSF budget was only $8 million.

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[37] Krieghbaum and Rawson, ibid., p. 98.

On the other hand, the Foundation had already developed the sort of extensive and elaborate dependence upon advice from outside committees and individuals that has come to characterize its operation, so that it was hard to exercise leadership from within NSF. Although Dr. Harry C. Kelly, assistant director for Scientific Personnel and Education, seems to have been convinced of the necessity of generating some sort of program to improve the science competence of high school teachers from the time of Dr. Buchta's first proposal, his means to this end was complicated. However, his methods were characteristic of the standard Foundation practice of waiting for strong, and apparently independent, outside advice before launching a new program or changing an old one. The many chance comments in conversations with outstanding scientists, the proposals from Buchta and others, and the advice from expert consultants, apparently were not enough to convince the most senior NSF officials of the need to initiate a program to retain high school teachers in science and mathematics.

A2. *Summer Institutes Begin for High School Teachers*

It seems that the impetus had to come from outside of NSF, possibly because of a lack of enthusiasm from the National Science Board, possibly because of internal politics and divided opinions within the Foundation about the propriety of being involved in the high school problem directly, or possibly because the Foundation generally preferred to follow outside opinion rather than to lead or to determine what that opinion should be. In any case, rather than designing and announcing a program, the Foundation waited until it received a proposal with such overwhelming outside support that it could hardly be criticized, especially if it were to be funded as an experiment rather than as the first grant of a deliberate program.

This proposal, from Dr. C. B. Allendoerfer of the University of Washington, was the result of Dr. Kelly's use of professional societies and other formal outside groups as advisors to the Scientific Personnel and Education Division. The Mathematical Association of America and the American Chemical Society apparently came to play a valuable role vis-a-vis the Foundation "* * * by stirring up interest in the institute idea, by helping to prepare and select proposals, and by the (sic) rounding up lecturers for institutes." [38]

In this case the direct link was with the National Academy of Science/National Research Council Committee on Regional Development of Mathematics, which had been created in 1952. Kelly had enlisted the committee's aid in 1952 in recommending college-level summer institutes in mathematics and in locating qualified people and institutions to submit appropriate proposals. The conference for college-level teachers of mathematics at the University of Colorado in 1953 had been the product of this committee's efforts.

In planning its recommendations for the summer of 1954, the committee felt that the time had come to try the idea of a summer institute for high school teachers in mathematics. Along with its other recommendations to the Foundation, therefore, there came the proposal from Dr. C. B. Allendoerfer of the University of Washington to hold an institute of four or five weeks duration to precede a meeting of the National Council of Teachers of Mathematics to be held at that university in late August of 1954. The idea as stated in the proposal was to have a conference:

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[38] Ibid. p. 113.

> . . . aimed at improving the quality of high school teaching in the country. Particular emphasis will be placed upon the mathematical preparation of students for college entrance, since all branches of science and engineering need a firm basis of high school mathematics for effective work in college. There are many ideas in the air relating to this aim, and it is hoped that this conference may offer an opportunity to pull these together and to serve as a real influence. It is proposed through fellowships to the teachers to attract a nation-wide group of teachers who can in turn influence the teaching in their own school systems.

To NSF, this seemed to provide a highly defensible opportunity to try a high school summer institute on an experimental basis without opening the door to an avalanche of requests that might have to be considered seriously. The credentials behind the proposal were impeccable; and at least one member of the Regional Committee pointed out that in future years the Foundation might say that the proposed conference had been funded because of its association with the later meeting of the National Council of Teachers of Mathematics, so as to restrict the future submission of proposals to one per year.

Under this aura of caution, a grant for $10,000 was eventually awarded. Then came concerns about the reaction of faculty in colleges of education, which turned out to appear favorable, and about the reaction of the Office of Education, which was pleased to learn of the experiment and to be invited to participate in evaluating the results. And so, approximately 2½ years after Dr. Buchta's strong formal recommendation, NSF embarked on what was to become one of its most popular programs, a program that has lately emerged as one of its most controversial efforts.

Fiscal year 1954 marked a significant change in funding for the NSF teacher education efforts. Whereas only $40,844 had been obligated in fiscal year 1953, the amount was $160,789 in fiscal year 1954. However, in summarizing activities of 1954 in the Annual Report, the Foundation gave little indication of the sense of urgency that surrounded the issue of high school education. To quote:

> The quality of science teaching at the secondary school level is of the utmost importance, for it is normally at the high school level that students first exhibit interest in scientific careers. More important, decisions are made at this time in selection of course work, such as mathematics, which is prerequisite to continuing scientific training in later years. Many organizations, both private and public, have studied the problem and generally agree that the high school science teacher has a unique opportunity to recognize talent early and to stimulate students toward more intensive science training at college and postgraduate levels. The teacher needs guidance and assistance, however, in carrying out his responsibility.
>
> During the past year the Foundation has continued to support Science Service, Inc., which administers the Science Clubs of America and science fairs on a local and national basis. This program provides a practical outlet for the scientific enterprise and imagination of young students and encourages and rewards them for their early scientific achievement. Science clubs are located in many of the States of the country and receive strong support from many community groups. The membership, now estimated at 300,000, continues to grow.
>
> The Foundation also sponsored an experimental Summer Conference for High School Mathematics Teachers at the University of Washington, Seattle, July 26–August 20, 1954. This conference, somewhat similar to the college institutes, was aimed at the high school teaching level and emphasized modern viewpoints in the teaching of algebra and geometry.[39]

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[39] Fourth Annual Report of the National Science Foundation, Washington U.S. Gov't. Print. Off., [1955] p. 56.

At about the same time, Dr. Eugene P. Northrop, a professor at the University of Chicago who had been hired on a consultant basis by NSF to run the Education in the Sciences (formerly the Research Education in the Sciences) Program, was to state as follows in his report on the success of the summer institute for mathematics teachers:

> The widening gap between demand and supply of teachers in the years ahead is appalling. We are faced on the one hand with a swelling population of school and college students and on the other with a shrinking population of school and college graduates prepared to teach. The shortage promises to be especially acute in the category of science teachers for secondary schools and small colleges, where discrepancies between teaching salaries and salaries in business and industry are greatest.[40]

It therefore would appear that the senior administration at NSF was still undecided about the Foundation's proper role in pre-college education in the fall of calendar year 1954. There was no mention of any plans for summer institutes for high school teachers in the 1955 appropriations hearings before the House of Representatives, held in the spring of 1954. The Foundation only requested $150,000 for the Education in the Sciences Program in fiscal year 1955, the same amount as requested in the previous year even though the overall NSF budget request sought an increase from $8 million to $14 million. This would have implied a reduction in science education support from the final 1954 obligation figure of $160,789. The Congress voted total appropriation for fiscal year 1955 of $12,250,000, and before the year ended the Foundation had redeployed funds to obligate $315,790 to Education in the Sciences.

This marked increase does not appear to have been the result of any independent decision on the part of NSF regarding the importance of science education. Rather, it seems to have resulted from direct action by President Eisenhower, who had learned of the growth of Soviet scientific manpower during a Cabinet meeting and who had therefore established a Cabinet-level body, the Special Interdepartmental Committee on the Training of Scientists and Engineers, to study the United States' situation and to seek solutions to reported problems. Dr. Arthur S. Fleming, Director of the Office of Defense Mobilization, was named chairman. On May 24, 1954 he appointed additional members as follows: Charles E. Wilson, Secretary of Defense Sinclair Weeks, Secretary of Commerce; James P. Mitchell, Secretary of Labor; Oveta Culp Hobby, Secretary of Health, Education, and Welfare; Admiral Lewis L. Strauss, Chairman of the Atomic Energy Commission; and Alan Waterman, Director of NSF.

Thus the Foundation was suddenly in a powerful association whose members would focus on finding workable solutions to the manpower problem without undue concern for the former priorities of the National Science Board or of the senior administration of NSF. According to Krieghbaum and Rawson:

> The agenda for the organizational meeting of the Special Interdepartmental Committee on July 21 [1954] listed five facets of the manpower problem:
>
> (1) Supply is well below demand for engineers and will be for the foreseeable future.
>
> (2) The number of science students is decreasing.
>
> (3) Universities are losing top-grade graduate students and many teachers to industry.

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[40] As quoted in Krieghbaum and Rawson, op. cit., p. 13'.

(4) High schools are having difficulty in building up a solid core of competent, inspiring teachers of science and mathematics.

(5) The nation needs to retain trained engineers and scientists in their specific fields.[41]

The report of the Special Interdepartmental Committee was delivered in October, 1954, and recommended, among other things, that the President:

> Direct the National Science Foundation, with the cooperation of other departments and agencies to: (1) continue to study and evaluate possible courses of action (whether or not delineated in this present report) which would tend to solve our scientific and engineering manpower problem; (2) emphasize programs within its responsibility which will contribute to a solution of the problem, and (3) provide leadership to other departments and agencies in developing plans and activities which will contribute to a solution of the problem.[42]

This coincided with the internal recommendations that Northrop had made to mount programs in Fiscal Years 1955 and 1956 that would provide:

(1) Stimulation and education of those now teaching science in high schools and colleges.

(2) Improvement of the high school and college science curricula.

(3) Identification, motivation, and counseling of high school students.

(4) Improvement of existing knowledge about scientific ability, its characteristics and identification, and the motivation and counseling of talented youth.[43]

Due to the unusual structure of NSF, the major changes which seemed to be demanded could not be made without approval of the National Science Board. In its November 5, 1954, meeting, the Board agreed with Waterman's proposed expansion of educational activity and authorized an increase in the planned budget request for fiscal year 1956 of up to $1.5 million. The Board stipulated that this might be used to augment the original plan of $500,000 for Education in the Sciences, or in other ways which might meet the education problem. This marked the turn in interest and policy, for science education has remained a major activity of the Foundation ever since.

In retrospect, it could hardly be said that the Foundation entered the pre-college education field on its own initiative. The problem was thrust upon it by circumstances, and responsibility to take action was resisted in spite of a broad and growing concern within the science community about the state of high school science education. In addition there is ample evidence that the senior administration of the Foundation and the National Science Board would have been pleased on a number of occasions to have surrendered this responsibility to any other auspices capable of performing the important job competently. On the other hand, it was at least clear in the middle and late part of the 1950 decade that science education could only be improved through the active participation of first-rate research scientists having a thorough command of the current knowledge in their respective fields. The improvement and maintenance of quality of the subject-matter included in science curricula, even at the precollege level, therefore became an activity of the scientific community rather than of the precollege educational community. Since NSF had a particular responsibility for education in the sciences, the Eisenhower administration felt that the Foundation would have to accept major responsibility, even at the hazard of having to direct some of its attention away from research and graduate education.

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[41] Ibid., p. 162.

[42] As quoted in Krieghbaum and Rawson, ibid., p. 165.

[43] Ibid., p. 160.

As mentioned above, the Foundation reassigned funds in Fiscal Year 1955 to expand its summer institute offering by a considerable amount. As opposed to four institutes the previous year, there were eleven in fiscal year 1955, six of which were for high school teachers. The Annual Report depicted events as follows, though it did not indicate the manner in which the interdepartmental committee had propelled events:

> Several years ago the Foundation learned through exploratory studies that a most critical and immediate limiting factor in developing latent science talent in the youth of the United States was the dwindling supply of adequately trained science teachers. In each succeeding year the proportion of college graduates qualified for high school science teaching has declined. Because of the unavailability of science teachers, many schools today have a limited science program or none at all. In other schools science teaching is on an emergency basis and many teachers have less than the minimum training required for certification.
>
> As this trend continues, the introduction of science to our potential young scientists becomes more and more inadequate and distorted. A poorly trained science teacher is unable to capture the imagination of his students, to formulate and teach them up-to-date and vigorous courses, and to guide their scientific development according to their abilities.
>
> In accord with these findings, the Foundation for the past 3 years has conducted a series of experimental programs to strengthen science teaching at the high school level.
>
> *Summer Institutes and Visiting Lecturers*
>
> For 3 years the National Science Foundation has sponsored a series of summer institutes attended by science teachers at both the high school and college level. The institutes normally ran for several weeks and the teachers attending them were given an opportunity to review recent developments in their respective fields of science under the guidance of leading scientists. The table below summarizes information on all institutes that have been held during this period.

National Science Foundation Summer Institutes

Host Institution	*Science Area*	*Participants*
1953		
University of Colorado	Mathematics	College Teachers.
University of Minnesota	Physics	College Teachers.
1954		
University of Wyoming	Chemistry	College Teachers.
University of North Carolina	Mathematics	College Teachers.
University of Oregon	Mathematics	College Teachers.
University of Washington	Mathematics	High School Teachers.
1955		
University of Wyoming	Biology	College Teachers.
University of Minnesota	Chemistry	College Teachers.
Syracuse University	Chemistry	College Teachers.
Syracuse University	Chemistry	High School Teachers.
Oklahoma A & M College	Mathematics	College Teachers.
Oklahoma A & M College	Mathematics	High School Teachers.
Stanford University	Mathematics	College Teachers.
University of Wisconsin	Mathematics	High School and College Teachers.
Oak Ridge Institute of Nuclear Studies.	Physical Sciences	High School Teachers.
Pennsylvania State University.	Physical Sciences	High School Teachers.
University of New Mexico	Physics	High School and College Teachers.

> The response of the teachers attending the institutes has been enthusiastic and the Foundation plans to continue this experimental program. During the past year, however, a grant has been awarded to the Bureau of Social Science Research, American University, to attempt to evaluate the effectiveness of summer institutes as a device for improving high school and college teaching of science.
>
> The Foundation has also provided several grants on an experimental basis to enable outstanding scientists to visit groups of colleges and lecture on recent research developments.[44]

That 1955 Annual Report went on to discuss the fact that only 40 percent of those having I.Q. scores of 120 or more in the proper age-group to go to college would actually finish college. The discussion pointed out that a cabinet level interdepartmental committee had been formed and "* * * has attempted to gather available information on the problem and to make recommendations for possible action. Clearly, the problem is not one that can be solved solely by action of the Federal Government. Education in the United States is almost entirely the responsibility of State and local governments and private groups and the social pressure required to improve or modify the educational system is generated in the citizenry itself."[45]

The discussion then described NSF research into the problem of how to get a larger fraction of the bright students to enter college; and concluded that a scholarship program might aid those bright students who wanted to go to college but who could not afford to (approximately 100,000 in number each year), but would provide no inducement to go to college for an equal number of bright students who did not want to attend. Presumably this consideration partly reflected NSF's authority to conduct a scholarship program, and partly the discussions of the interagency committee. In any case, the national awakening in science in the late 1950's ameliorated the concern over this matter.

In a very short space of time, science manpower problems became a matter of recognized importance. In July 1955, Dr. Waterman released results of a survey on the impact of the shortage of scientists and engineers on industrial research. The survey, conducted by the Bureau of Labor Statistics of the Department of Labor, reached 11,600 companies, and contained extensive examinations of problems in 200 of the largest of these companies. The report noted that:

> The shortages of scientific and engineering personnel reported by many companies represented, in most cases, a demand for additional staff for current research programs; in others, a need for additional personnel to permit a planned expansion in research activities. Approximately one-third of the companies interviewed reported major or substantial numerical shortages of research scientists and engineers. About one-sixth of the companies reported shortages of a less extensive character. The remaining half of the firms said they did not have numerical shortages of personnel, but many companies in this group emphasized their need for scientists and engineers with more advanced training or better professional qualifications. Officials of several of these firms said they would expand their research and development activities if well qualified or better trained persons could be found.
>
> Lack of sufficient scientific and engineering personnel was reported, in many instances, to have hindered companies in carrying out going research programs. A sizable though smaller number of firms said they had been forced to curtail projected increases in their research and development activities.

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[44] Annual Report of the National Science Foundation, Fiscal Year 1955, Washington, U.S. Govt. Print. Off. [1956]. pp. 70, 71, 72.

[45] Ibid. pp. 71 and 72.

The proportion of companies reporting shortages of research and development scientists and engineers was largest, as previously noted, in the aircraft, electrical equipment, petroleum, paper, food, and primary metals industries. * * * [46]

But soon after this another report was to be issued that would have far greater impact in promoting the growth of NSF's pre-college education efforts in size and diversity. This was a study by Nicholas De Witt entitled "Soviet Professional Manpower—Its Education, Training, and Supply," [47] the latter part of which had been conducted under NSF sponsorship.

Advance copies of the report were available at the time of the NSF appropriations hearings in the House of Representatives, though apparently they had not yet been distributed to Congress. Members of the Subcommittee of the House Committee on Appropriations were clearly skeptical of De Witt's results, as quoted by Waterman. The following interchange is illustrative:

Dr. Waterman. * * * At the same time there is every reason to believe that the U.S.S.R. has already surpassed us in the production of engineers and is on the way to doing so in the production of scientists.

Mr. Thomas. I notice that you, 2 or 3 times, refer to that throughout your justification. How much is fact and how much is fiction? How did you arrive at that statement?

Dr. Waterman. While there is some uncertainty as to exact figures, there are various ways of getting at information.

We have a fairly clear idea now of what is happening in a general way. For example, we do know that they apparently have passed us in their output of engineers in 1952 and are now ahead of us.

Mr. Yates. How do you know that?

Dr. Waterman. That was in their 5-year plan, and as evidenced by the graduation from their schools.

Mr. Thomas. How do you get that information?

Dr. Waterman. In various ways. These are public statements where they are mentioning their accomplishments. Others are from travelers and various sources of information which we put together.

Mr. Thomas. What are their public utterances in the field of information which makes it any different in relation to this activity? We have had a lot of experience with them in their other statements. We find that that is just not worth the paper it is written on. How do you reconcile your statement that they are ahead of us in this field or that field, when no one knows the truth of it?

Dr. Waterman. We have their 5-year plan, in fact, a succession of 5-year plans for education. We have the benefit of people who have been there traveling. There was a book written on the subject by an Australian who was attached to the Embassy there. I have a summary of information which came out in Business Week as the result of an interview with me. Recently the Harvard Review came out with a report which was abstracted, a digest of it, by Nicholas De Witt in Aviation Age, which represents some of their findings. Of course, one cannot go into all sources of information by which this is received.

We have to make a compilation of what we can get. Things like this are fairly clear, things such as are stated in this article by De Witt. We have copies of this for members of your committee, if you like.

Mr. Thomas. What is the basis of his information? People travel from this country into that country, but the bridle is put on them when they get there. They are shown the things they want them to see. I do not see how you can put too much credence in any of their propaganda.

Dr. Waterman. I think we can count on this, Mr. Chairman, they have a larger population than ours, and they are evidently making a drive in education.

Mr. Thomas. Do you have any information of what they are doing in the public school system? Do they have a public school system?

Dr. Waterman. They do. We understand that 40 percent of the time of high-school students is devoted to required science, that if they fail to pass two courses they are dropped. All along the way there is a selective process. We know from news-papers that they likewise play up scientists and scientific activities. This is front-page news.

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[46] As reprinted in the Congressional Record, v. 101, July 27, 1955, p. 11626 and ff.

[47] De Witt, Nicholas. Soviet Professional Manpower—Its Education, Training, and Supply. National Science Foundation, Washington, U.S. Govt. Print. Off. [1955]. 400 p.

So far as we can find out in their treatment of scientists, the scientists rank about No. 3 in occupational standing, salary and so on. I should say the engineers rank about that. They rank college professors and statesmen higher than that. Every evidence is that they are doing the utmost to develop their science as a source of economic strength and a strength in defense.

Mr. THOMAS. I think the evidence at hand will substantiate that statement. As to the results they are producing and the numbers, that is something else.[48]

Though that element of disbelief about the strength of the Soviet thrust in Science would soon vanish, the subcommittee chairman, Mr. Thomas, raised a fundamental issue that has continued to be a problem:

Mr. THOMAS. Here is a pretty good place for me to say this. I have read your justifications carefully. I was struck with two outstanding thoughts. One is that it is not going to be very long before you have a charge thrown in your face, and you are going to have a hard time defending it, that the National Science Foundation is trying to take over in this country the colleges and the universities and lay down the pattern and control, through a Federal bureau in Washington, the education and training of college students and scientists. That is No. 1.

No. 2 is that a large part of this justification is predicated on fear of what Russia is doing. Those are the two main reactions that we get out of your justifications.

Dr. WATERMAN. On the first one, Mr. Chairman, I hope we make ourselves quite clear. I am sure our friends and colleagues in science and in the universities know that we are not planning to mastermind the educational pattern from Washington. You will notice we have no large educational program which we are trying to operate from Washington.

Mr. THOMAS. You jump from about $200,000 4 years ago up to $20 million.

Dr. WATERMAN. This is not all training. The education and science program is largely a matter of conferences and studies to determine what should be done.

Mr. THOMAS. That is where you start.

Dr. WATERMAN. This is available to everyone. We would expect that universities and colleges in their neighborhoods——

Mr. THOMAS. It is what you lay down. You offer this bait to the colleges and universities, "If you want this money, you take it through this channel. We are the mastermind. This is what we want you to do. If you want this money, you do this, or you do that or the other." Is that correct?

Dr. WATERMAN. No, sir; I would not say that.

Mr. THOMAS. What would you say?

Dr. WATERMAN. The people holding the conferences——

Mr. THOMAS. I am talking about schools and universities. You lay down the pattern for what you want them to do.

Dr. WATERMAN. No, sir.

Mr. THOMAS. Then you send your people in there to see that they do it. You call it a discussion with them, an evaluation, and so forth.

Dr. WATERMAN. The discussions are not primarily our staff. They are by the people concerned in the educational field.

Mr. THOMAS. They are your agents and doing what you want them to do.

Dr. WATERMAN. They are doing what they wish to do. We try to follow their plans. These are thrown wide open for them to determine for themselves what they think is the advantageous thing to do.

Mr. THOMAS. Before you pass out this amount of money to the university, you lay down the pattern, do you not?

Dr. WATERMAN. We certainly do not here. We have several checks on that. We have additional committees appointed by the Board. These are part-time people who are authorities in their fields from all over the country. They are the ones that advise us with respect to what should be done. We also have our Board, which is highly representative of all sections of the country. They pass on these plans, too.

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[48] U.S. Congress. House. Subcommittee of the Committee on Appropriations. Independent Offices Appropriations for 1956. Hearings 84th Congress, 1st session. Washington. U.S. Govt. Print. Off., 1955 p. 230 ff.

Mr. **Thomas.** When they deal with X institution, they speak as representatives of the National Science Foundation; is that correct?

Dr. **Waterman.** In any program of the Foundation, they do; yes, sir.

Mr. **Thomas.** That is what we are talking about.

Dr. **Waterman.** The plan of conferences and studies is worked out by the scientists and educators and not by us. We are only the agent which makes them possible. We take their recommendations. Our whole effort is to see to it that this is done by the people who are directly concerned. I, personally, am very much interested, Mr. Chairman, in avoiding any dictation on the part of a Federal agency in the field of education. That is why we have not proposed a general plan with a great deal of money in the field of education. We are trying to determine what it is the scientists feel should be done. These studies are made by the scientists, by the university people, and by the industry people, to determine what they think is the right thing to do.[49]

Judging by these statements, Dr. Waterman apparently felt that the National Science Foundation was administering its educational programs in a way that gave considerable insurance against charges of Federal manipulation of school and community affairs. However, the system had serious weaknesses that would impair the effectiveness of the Foundation's leadership and would remove it from important areas of decision. In 1975 those weaknesses would result in major questions about the Foundation's management of its education programs. Though descriptions of specific events leading to these questions will be presented in their respective chronological contexts at other points in the text, it seems appropriate here to give a brief summary of the nature of the general management problems that would lead to trouble.

A3. Principles of Program Management

In order to understand the Foundation's management approach, it is worth remembering that NSF's central interest is basic research. NSF feels that it is the only agency whose mission is to promote basic research without regard to immediate or eventual utility. It has primarily been staffed and run by scientists, most of whom are either directly from an academic background or who have a strong interest in academic science. As a result, the management practices adopted in 1950 and shortly thereafter, and many of those practices existing today, bear a similarity to practices found in academic management.

Such practices were primarily designed for the administration of basic research, which would seem appropriate for NSF. They have been structured to allow for a great deal of individual discretion by those doing research, on the assumption that the full exercise of intellectual creativity can only occur when researchers are free from having to adhere to definite objectives and definite schedules of progress. Since each research investigator is presumed to be an authority in his or her own sphere, it has been presumed to be unnecessary, and possibly counter-productive, to require a grantee to seek approval for decisions, either major or minor, affecting the conduct of his or her research.

The National Science Foundation designed its own management procedures to reflect these principles. Its research grants have been, in a very real sense, monetary awards to scientists who 1) have been deemed to be competent and 2) have proposed worthwhile research projects—both matters being judged primarily by other scientists known to be expert in the fields in question or in closely related areas, and who were not themselves members of the NSF staff. Once a grant is made, the grantee has been under little formal obligation to meet any particular objectives or, in principle, even to work on the problem originally proposed to the Foundation. The principal hazard faced by the grantee has been in having to obtain favorable opinions from the scientists who would review his or her next proposal. Unfavorable opinions would mean that the next proposal would presumably be declined.

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[49] Ibid., p. 234, 235.

The Foundation itself has traditionally avoided evaluating the performance of grantees, except in determining whether another grant would be awarded to a given scientist. In this way the Foundation has allowed the scientific community to control its own affairs and has avoided exerting undue influence. In NSF's view, the success of a basic research project is determined by whether other scientists find the results useful, and this comes about through the publication of research results in professional journals.

Though regulations relating to grants have become more formal with the passage of time, the basic principles of NSF administration remain much the same. While NSF now reserves the right to approve certain decisions of the investigators it supports via grants, the emphasis is definitely on permissiveness and non-interference. In consequence of procedures established by the OMB for all Federal agencies making grants, NSF issued a grant administration manual in 1973. It set forth the following rules:

PROJECT OR GRANT CHANGES

400. CHANGES IN METHODOLOGY OR OBJECTIVES.

401. Background

A key factor in the NSF decision to support a project involves the broad objectives of the proposal in terms of the areas of scientific knowledge to be advanced or other aims to be achieved. The methods and procedures employed in reaching those goals and the specific early objectives also are of importance in many program areas. The Office of Management and Budget, in its Circular No. A-101, recognized two principal types of projects supported by assistance-type Federal awards:

Type 1: Those for which the course of the work is not defined precisely and specific points in time for achievement of results are not spelled out, but the principal objectives are stated. For such projects, the institution bears primary responsibility for the conduct of the project and should exercise judgment toward attaining the stated objectives within the limits of the resources provided.

Type 2: Those for which detailed objectives or goals are specified in advance by the Government or for which the Government otherwise considers it necessary to be able to exercise close control over the direction, specifications, methods or schedules of the project.

NSF believes that the Principal Investigator or Project Director operating within established grantee policies should feel free to pursue interesting and important leads which may arise during the conduct of a scientific research project, or to adopt an alternate approach which appears to be a more promising means of achieving the objectives of various other Type 1 projects. On the other hand, the award instrument for Type 2 projects may provide for a degree of NSF review and direction appropriate to achievement of the goals or objectives stated in the applicable program announcement.

402. Basic Restrictions

402.1. Neither the broad category of research nor the objectives of the projects stated in the proposal (or agreed modification thereto) shall be changed without prior NSF approval.

402.2. Significant changes in methods or procedures shall be reported to the cognizant NSF Program Officer. However, the award instrument for Type 2 projects may require advance coordination with the cognizant NSF Program Officer and specific NSF approval before such changes are undertaken.[50]

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[50] NSF Grant Administration Manual. National Science Foundation, Washington, D.C., October 1973, NSF 73-26.

Thus a person supported by an NSF grant still has practical autonomy under section 401; and in practice the restrictions cited in section 402.1, and generally under 402.2, are customarily administered quite informally at the sole discretion of a single program officer whose interest is directed primarily toward awarding new grants, rather than toward monitoring existing grants.

As Dr. Waterman's statements indicated, NSF attempted to apply these same principles to its education programs. This would seem to explain something about why the impetus for mounting the pre-college programs had to come from outside the Foundation, in spite of very strong internal advice from a number of staff members. It would also explain why Dr. Waterman seemed unaware of the possible negative consequences of failing to devise procedures which would ensure that NSF would maintain control over sensitive questions in its education programs.

There have been a number of times when events might have prompted NSF to review its procedures and to establish methods which would have provided such control. This could have been done in ways that might have protected a good deal of the autonomy of those who ran the various institute programs, and of those who would later engage in curriculum development. But as the Foundation extended its support to the development of curricula, and then to the instruction of those curricula to teachers, and finally to assisting in the implementation (i.e., the adoption and initiation of pupil instruction) of its own curricula in school systems, it still operated on the basis that grantees should make the policy decisions relating to their grant-supported activities. As a result, the mechanisms for self-correction were weak. When criticism erupted in the spring of 1975, the Foundation could only reiterate Dr. Waterman's statement of 1955 (quoted above):

> The plan of conferences and studies is worked out by the scientists and educators, not by us. We are only the agent which makes them possible.

And as that agent, NSF found it difficult to explain why it did not have authority over the ultimate uses of the Federal funds appropriated to it.

B. PRE-COLLEGE SCIENCE EDUCATION BEGINS TO ATTRACT NATIONAL ATTENTION: 1956–1957

Though the Foundation's pre-college education efforts seemed strongly established in 1955, events of the next few years would make this earlier period look miniscule in terms of the size of the program, its breadth of objectives, and its philosophy. In spite of the indications of congressional skepticism about the Soviet educational situation in the appropriation testimony for Fiscal Year 1956, and in spite of congressional concern about undue influence of the Federal Government in local school affairs, the 1956 program in Education in the Sciences totalled $1,416,820 as compared to $315,790 the year before. In consequence of this expansion, the NSF program titled "Education in the Sciences" was now formally structured into three sub-programs: Teacher Programs ($1,119,970), Student Programs ($279,440), and Curriculum Programs ($17,410). The Teacher Programs consisted primarily of summer institutes, now 25 in number as opposed to 11 the year before:

National Science Foundation Summer Institutes, 1956 [51]

Host institution	Science area	Participant
Wisconsin State College at Eau Claire.	Astronomy	High school and college teachers (primarily for teacher-training instructors).
Indiana University	Biology	High school teachers.
University of Utah	Biology	High school and college teachers.
Botanical Society of America, at Cornell University.	Botany	College teachers.
Indiana University	Chemistry	College teachers.
Montana State College	Chemistry	High school and college teachers.
Oregon State College	Chemistry	College teachers.
Iowa State Teachers College	Mathematics	High school teachers.
University of Michigan	Mathematics	College teachers.
Williams College	Mathematics	High school and college teachers.
American Society for Engineering Education, at the Argonne National Laboratory (cosponsored with AEC).	Nuclear Energy	College teachers (engineering instructors).
American Society for Engineering Education, at the Brokhaven National Laboratory (cosponsored with AEC).	Nuclear Energy	College teachers (engineering instructors).
University of Arkansas	Natural Sciences	High school teachers.
American University	Physical Sciences	High school teachers.
Marshall College	Physical Sciences	High school teachers.
Oak Ridge Institute of Nuclear Studies.	Physical Sciences	High school teachers.
Oak Ridge Institute of Nuclear Studies.	Physical Sciences	College teachers.
University of Rochester	Physics	High school teachers.
University of Wyoming	Physics	High school and college teachers.
Duke University (cosponsored AEC).	Radiation Biology	High school teachers.
Harvard University (cosponsored with AEC).	Radiation Biology	High school teachers.
University of New Mexico (cosponsored with AEC).	Radiation Biology	High school teachers.
Alabama College	Science	High school teachers.
Pennsylvania State University	Science	High school teachers.
Wesleyan University	Science	High school teachers.

[51] 6th Annual Report of the National Science Foundation, fiscal year 1956, National Science Foundation, Wash., 1957.

B1. Academic Year Institutes Begin

Approximately 1,300 teachers attended. Meanwhile, the Foundation was planning to host 95 summer institutes for approximately 4,750 teachers in fiscal year 1957. In addition, fiscal year 1956 marked the inauguration of the academic year institutes for high school teachers of science and mathematics. Under this program, a teacher could receive a stipend and other support from NSF, while on a leave of absence from his or her teaching job, to take a special program of study at a university during the academic year. Two grants were awarded, one to the University of Wisconsin and one to Oklahoma A and M College, both to take place in the 1956–1957 academic year.

The course work in these institutes was designed to be applied toward requirements for the master's degree.

The other programs under "Education in the Sciences" also reflected the imaginative thinking that had been going on behind the scenes at NSF. The Visiting Scientists Program, which was to become an important part of the Foundation's efforts at the undergraduate level, was implemented in 1956 with offerings in mathematics, chemistry and biology after a pilot effort in mathematics in the academic year 1954–55. A high school level counterpart of this program was also initiated with funds from fiscal year 1956, using specially trained science teachers as traveling lecturers in the 1956–57 academic year. Science clubs and science fairs in high schools were given continued support with a grant of $40,000 from fiscal year 1956 funds.

B2. Curriculum Development Begins

Fiscal year 1956 also marked the beginning of another important Foundation effort: curriculum development. The National Science Foundation's 6th Annual Report (fiscal year 1956) describes the activities of that year:

> Several conferences and colloquia held during the year served to bring together educators, scientists, and Federal officials who sought to improve science curricula and teaching methods. Notable were the Colloquium of College Physicists; the Conference on the Identification of Creative Scientific Talent; the Conference of Summer-Institute Directors; a conference of executive officers and educational committee chairmen of professional scientific societies designed to encourage the selection of technical careers and improve the training of talented students; and a conference on teacher education in the sciences sponsored jointly by the American Association for the Advancement of Science, the United States Office of Education, and the Foundation convened to exchange ideas on the improvement of science teachers, to explore ways to bring about better understanding between scientists and professional educators, to plan courses of cooperative action, and to consider possibilities for new ways of training science teachers.

It would thus appear that the events of 1955 had produced a considerable change in viewpoint at NSF. Now that the order had been given to improve pre-college education, the Foundation approached the matter with exhaustive thoroughness. Its former reluctance to plan creatively seemed to be replaced by an apparent eagerness to have a program for every conceivable problem in pre-college science education. While this is an overstatement, the contrast in viewpoint made it appear that NSF was prepared to try almost anything.

B3. Congress Enlarges the Institutes

A part of NSF's new-found confidence was a result of the hearings on behalf of its budget for fiscal year 1957 before the House Committee on Appropriations in the spring of 1956. For the first time, the Foundation found itself in the unexpected position of having an offer of more money than was requested. The budget submission for fiscal year 1957 was bold in comparison to the operating level for Education in the Sciences in fiscal year 1956: $5,375,000 as opposed to an obligation of about $1.42 million for 1956. The 1957 budget justification contained the following description in its introduction:

> *Education in the sciences.*—The Foundation's program of education in the sciences is concerned with the problem of providing the necessary supply of competent scientific manpower which will be so urgently needed in the years ahead. Since training of a scientist or a science teacher is a long-term process, from the high-school years through undergraduate and graduate study, the problem must be attacked on a long-term basis. Basic experimental programs

> in this area are focused at the problems of strengthening present science teaching, improving science curricula and teacher training and early identification, motivation, and counseling of able students with scientific aptitude to pursue careers in science and science teaching. The amount requested for fiscal year 1957, $5,375,000 represents an increase of approximately $4.1 million over 1956, and provides for expansion of going programs to a more effective level. Of the amount requested, $3 million is aimed at strengthening present high-school science teachers by means of an experimental supplementary training program, which contemplates the support of specially designed year-long courses of study at selected universities for high-school science teachers, and financial assistance to selected high-school science teachers which will enable them to undertake such additional training.

However, by this time the impact of Nicholas De Witts' book, "Soviet Professional Manpower," was well developed and the members of the Subcommittee of the House Committee on Appropriations considering appropriations for Independent Offices, chaired by Mr. Thomas, felt that the Nation's educational response should be commensurate with the apparent need for science teacher training. Three million dollars for the academic year institutes did not seem to be enough to the subcommittee, but this came as a total surprise to the Foundation. In introducing the subject of education for teachers, Dr. Detlev Bronk, chairman of the National Science Board, tried to respond to the committee's doubts of the previous year:

> I am one of those who has said that I think we should not say we are going to do this or we are going to do that, because the Russians are doing it. I think we are a country that can stand on our own feet and make our own decision.
>
> But, nevertheless, having been 1 of the 5 representatives to Geneva at the Peace Conference last year, I feel I have an obligation to say that I was shocked by the necessity for reversing my previous opinion.
>
> I had thought that the Russians were so crude in their approaches to education and science that we did not have anything very much to worry about from them. I thought that a lot of people had said much more than the Russians deserved with regard to their competence. But I was certainly strongly impressed by the fact that they had been able to do many things that I did not think they could do.
>
> Furthermore, I was impressed by the fact that we heard over and over again that they are increasing more and more the number of students who are taking science and are being trained in science and in engineering. I think that this is almost a necessity for any country which desires to hold itself high in a modern scientific and technological age.
>
> Every new development unfolds other developments, and the only way we can cope with these new scientific and technical developments is to have people who are competent to deal with them.
>
> Mr. THOMAS. This little book, Soviet Professional Manpower, I read word for word, including most of the tables, and after reading it I completely reversed my thinking, too, just like you said you reversed your thinking.
>
> Of course, we do not have to tie it to Russia by any means, but we found out what Russia is doing. This is the most alarming situation that I can imagine. I think I speak for the committee that if we are going to be with the Foundation when the Foundation starts out on some new programs, we are going to encourage and help you. But this Russian progress is the most startling thing I know of.
>
> If this is true, and I have no reason to doubt what is said in this book, in another 5 to 6 years they are going to be ahead of us. Lord help us if they ever reach the point where they are ahead of us, and they are too close to us now.
>
> Certainly you ought to pursue this new program that you started for the training—I think the word "refresher" is not a very accurate word—courses for your high school instructors which is estimated to cost $3 million this year. If you can use $9 million or $10 million, we are certainly prepared to give it to you.
>
> You are really striking at something worthwhile.
>
> My own thinking toward the Foundation in the past has been that you have been living in the past. You have been doing too much bookkeeping work to find out what has been done in the past.
>
> Let's forget that. The past is prologue and it may have some value. You are striking out on something new now. You are going right at the fundamental thing.

this shortage that is created by a lack of high-school teachers. When you start doing work like that, you are really striking something that is of value to the whole Nation.

> The other program of supplying funds for research equipment, whether or not the committee is going to push along that line, too, in the way of encouraging you I do not know. But get away from evaluating past work and spending four or five hundred thousand dollars in bookkeeping, evaluating, and sifting here and there.
>
> I think you have a fine program but I believe you can cut out some of your paperwork. Train your manpower, that is what you need.[52]

Somewhat later in the hearings, Congressman Boland seemed to anticipate a conclusion that the Foundation would reach a few years later. Considering the need to stimulate students into the study of science and mathematics, he spoke as follows:

> Mr. BOLAND. Would not the stimulation have to go back beyond the high-school teacher?
>
> A student graduates from high school, but I think his attitude toward mathematics is developed not in high school but in grammar school. I do not know what the Foundation can do about it, but it would seem to me that their ought to be greater emphasis on the local level to try to get the student to like mathematics. If he goes into high school and the teaching is good, then you have it.[53]

This undoubtedly was taken by NSF officials as a strong encouragement to pursue the problem of pre-college education as far as seemed reasonably necessary. Since fiscal year 1956 was not yet over, at the time of these hearings such encouragement may have accounted for some of the broader viewpoint exhibited by NSF in that year.

Before the hearings concluded, the committee and NSF had made a bargain: the academic year institutes (referred to in the testimony as the high school teacher training program) would be escalated from the proposed level of $3 million to $10 million over a three year period, and the summer institutes would be raised from the proposed level of $850,000 to $3 million in fiscal year 1957. The discussion went as follows:

> Mr. EVINS. Could you use $10 million instead of $3 million for the high school teacher training program at this time?
>
> Mr. WATERMAN. I believe we could
>
> MR. EVINS. In the fiscal year 1957?
>
> Mr. WATERMAN. I believe so; do you not think so, Dr. Kelly?
>
> Mr. KELLY. Ultimately. One of the programs that we are most enthusiastic about is this summer program, the free time of the teachers during the summer, which we could and probably should exploit to the limit of expending the summer institute program in such a way that we can do three things: One, to increase their subject matter knowledge of the science, make them feel a part of the community of science, getting better relationships between the high schools and colleges and then, in addition, to increase their yearly salary in keeping with their monthly salary so they will not have to go out tending gasoline stations during the summer. So that we could expand this program.
>
> Mr. EVINS. In other words, the Foundation is staffed and ready to move if it has the funds to go forward?
>
> Mr. WATERMAN. Yes.[54]

Then, continuing in detail:

> Mr. BOLAND. . . . 1956 is the first year for the high school science teachers' training program?
>
> Mr. WATERMAN. Yes.

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[52] U.S. Congress. House. Subcommittee of the Committee on Appropriations. **Hearings. Independent Offices appropriations for 1957** Washington. U.S. Govt. Print. Off. 1956. p. 522, 523.

[53] Ibid, p. 526.

[54] Ibid, pages 611, 612.

Mr. BOLAND. How many teachers are in training now? You have two universities in the program, Oklahoma and Wisconsin.

Mr. WATERMAN. It will not be started until the next academic year. They are making thier plans now and we expect 50 students each.

Mr. BOLAND. If this item were increased from 3 to 10 million dollars would it not present a problem to the local high schools as the program would be taking teachers away who would be needed back home?

Mr. WATERMAN. That is one thing that has to be reckoned with, of course.

Mr. KELLY. It is less than 1 percent of the high school teachers that would be involved in these 10 year-long institutes.

Mr. BOLAND. If the amount were increased to $10 million, what would be the percentage?

Mr. KELLY. That would be something around 2 percent.

Mr. GROSS. Was not Dr. Waterman's reply as to the ability to use $10 million on the basis of a 3-year program?

Mr. WATERMAN. Yes.

Mr. GROSS. I doubt whether the Foundation could take $10 million over the next year and wisely spend it. However, over a 3-year period, we could do it.

Mr. WATERMAN. That is quite right.

Mr. KELLY. That is for that particular program, the year-long institute.

Mr. GROSS. The summer, however, is a different question, and that could be expanded very markedly.

Mr. THOMAS. What is your best guess as to what you could use on the summer program, and the year-long programs.

Mr. GROSS. I hesitate, but I should think on these figures here you have a ratio of $3 million for the present program we are talking about, and this would have the effect of stepping it up 3 times to $10 million over 3 years.

Mr. WATERMAN. That is quite feasible, I think.

Mr. GROSS. I think you could apply the same ratio and still be sound. $3 million or something of that sort per year on the summer program.

Mr. WATERMAN. I should think so.

Mr. KELLY. It would be my guess.

Mr. GROSS. This is a great need; no doubt about that.

Mr. THOMAS. I am not clear on that point. As it is, you have less than 100 teachers. You are going to step this up and have 200 more?

Mr. GROSS. 1,200 ultimately.

Mr. THOMAS. I am talking about the next fiscal year with the way your budget stands now, you would be giving some type of training to about 300 high-school teachers, which is not a drop in the bucket.

Mr. WATERMAN. Yes.

Mr. THOMAS. The question is, How many universities can you get in line where they can get a program going, and how many can they train over and above what you have set out in your 1975 budget?

Mr. WATERMAN. Based on the inquiries that we have, I should think we could raise this from 3 to 10, and give them the year.

Mr. BRONK. I think this is going to have a lot of effect in setting the pattern that the others will follow.

I cited the instance here this morning that the University of Pennsylvania is going to have a high-school teachers' training program in the sciences there on their own. In the Pittsburgh area, having seen what has happened here in Washington, they are going into it.

So what we are doing is putting out seed corn that, if we get a good crop of corn, a lot of other people will start to plant.

Mr. THOMAS. Dr. Waterman, when you and your group get back to the office, send us a little note in the mail tomorrow on this, please.

Mr. WATERMAN. All right, sir.

Mr. GROSS. Mr. Thomas, I think the limit is not anywhere in the area of just multiplying these figures by three.

Mr. THOMAS. As I indicated this morning, we realize that it is one thing to say that you are going to get X number of teachers to go to school, but is another thing to say you will have that university prepared to receive them. Your bottleneck will be in the universities. It is not the number of teachers. Instead of 300, you can get 10,000 or 15,000. It is a question of having facilities available.

Mr. GROSS. There is a good point I might mention in passing, and that is that the enrollment in summer schools all over the country has been on a decline, a substantial decline, until this past year. It is about evened out and beginning to come up.

> The housing capacities and facilities are there and they are not using them in the summer schools of the universities.
>
> Mr. THOMAS. It would be a good year to hit it heavy then.
>
> You give us some information on that in black and white.[55]

However, this agreement with the committee came at a cost. The House appropriation bill, H.R. 9739, reduced the total proposed NSF budget for fiscal year 1957 to $35,915,000 from the original request of $41,300,000 while including the requirement that not less than $9,500,000 be spent on "tuition, grants, and allowances in connection with a program of supplementary training for high school science and mathematics teachers."

The increase for high school teacher education, coupled with the overall budget decrease, seemed to Dr. Waterman to require a $6,460,000 reduction in research grants and a $3,500,000 reduction in research facilities support. NSF took its case to the Senate, which had yet to hold authorization hearings.

Alan Waterman wrote a detailed letter on March 16, 1956 to Senator Warren Magnuson, chairman of the Subcommittee handling Independent Offices, of the Senate Committee on Appropriations complaining of the provisions in the House appropriation bill.[56] His argument was that science support must be balanced, not only between research and education but also between various levels of education. Waterman complained that the Foundation's balanced and considered program had been upset, that important educational factors had been omitted from H.R. 9739.

On the other hand, a number of other factors deserve consideration. The first is that the Foundation was requesting an appropriation increase from about $16 million in fiscal year 1956 to $41.3 million in fiscal year 1957. The second is that, with the exception of the minimum obligation of $9.5 million stipulated for high school teacher training by the House, the Foundation did not have a line-item budget and was quite free to adjust funds internally. Thus the claim of imbalance was only merited in a limited sense.

At the levels set in H.R. 9739, it would appear that the Foundation could have performed its mission with substantial increases in every program area, so it would seem that Waterman's protest may have been a further indication that the Foundation and the National Science Board were primarily concerned that high school education might replace research as the prime function of NSF.

The Senate complied with Waterman's request to recommend appropriation of the full $41.3 million request and to delete the requirement that $9.5 million be spent on a program of supplementary training for high school science and mathematics teachers. The final bill, after conference, appropriated a total budget of $40,000,000, *including the stipulation that $9.5 million would be reserved for teacher training* (and that $3.5 million was included for a radio astronomy facility). Education in the Sciences was now a major effort, with a total budget of almost $11 million for fiscal year 1957.

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[55] Ibid., pages 613, 614.

[56] Reprinted in the Congressional Record, V102, 86th Congress, 2d session, June 6, 1956, p. 9635 ff.

B4. The FY 1957 Pre-College Programs: The First In-Service Institutes

More money for education meant more programs as well as larger efforts within programs. Three forms of institutes were available: summer, academic year, and in-service. Administration became more elaborate as well. And fiscal year 1957 produced other important changes. The Seventh Annual Report of the National Science Foundation gave a good summary of the education activities and management for fiscal year 1957:

> ### 1. INSTITUTES PROGRAM
>
> #### SUMMER INSTITUTES
>
> Pursuant to strong congressional endorsement of the program, the number of summer institutes was greatly increased for the summer of 1957. Ninety-six summer institutes were supported by the Foundation—87 for high school teachers of science and mathematics, 5 for college and junior college teachers of science and mathematics, and 4 for participants from both groups. The 96 institutes chosen for support were selected from a total of 189 proposals. Attendance at the institutes was slightly in excess of 5,300 teachers.
>
> Review and evaluation of proposals was accomplished by advisory panels chosen from individuals recommended by the Nation's scientific societies as being highly qualified to render judgment in questions involving education in the sciences. Panel members represented all fields in the natural sciences, including mathematics; industrial as well as educational institutions; high school teachers and officials from State departments of public instruction. Final selections carefully observed the directives from Congress "to avoid undue concentration" of support for education in the sciences.
>
> During the summer of 1957, summer institutes were held in 43 States and in 3 Territories—Alaska, Hawaii, and Puerto Rico. There were 16 in New England and New York; 19 in the other Eastern States; 16 in the Southeast; 15 in the Midwest; 10 in the Rocky Mountain and Northwest region; 17 in the Southwest, including California; and 3 in the Territories.
>
> #### ACADEMIC-YEAR INSTITUTES
>
> A total of 16 academic-year institutes, to begin in the fall of 1957, were supported by the Foundation in fiscal year 1957.* * * Most courses in science and mathematics offered by these schools are especially designed for the high school teacher who wishes to upgrade his training in the subject matter of the science or sciences he teaches. Most schools provide curricula leading to such degrees as master of science in science education. Approximately 775 teachers will be trained in the 1957–58 program. There were available appointments for only about 15 percent of those who applied. The Foundation plans to carry forward a program of essentially the same magnitude in academic year 1958–59.
>
> #### IN-SERVICE INSTITUTES
>
> This is a new program for which support was first offered in fiscal year 1957. This kind of institute is designed to meet the needs of supplementary subject-matter training for teachers of science and/or mathematics while they are teaching. Meeting one evening per week or on Saturdays during the academic year, such institutes will usually provide approximately 4 semester-hours credit. Classes are generally small and participants are drawn from a 50-mile radius of the host institution. Fifty-nine proposals were received, and 21 were granted support to begin in the fall of 1957. Approximately 850 teachers are expected to attend.
>
> ### 2. SPECIAL PROJECTS IN SCIENCE EDUCATION
>
> These activities fell in three areas.
>
> (A) Curricula Studies, (B) Student-Participation Projects, and (C) Teacher-Training Projects.
>
> #### CURRICULA STUDIES
>
> These studies seek to respond to the concern, often expressed by scientists and educators, over failure of instructional programs in primary and secondary schools to arouse motivating interest in, and understanding of, the scientific disciplines.

General agreement prevails that much of the science taught in schools today does not reflect the current state of knowledge nor does it necessarily represent the best possible choice of material for instructional purposes.

One of the most exciting activities in high school science education today concerns the development of an entirely new curriculum in physics for use in the high schools. This venture has been undertaken by a rather large group of senior physicists with a similar number of high school science teachers working together. This project happens to be under the administration of the Massachusetts Institute of Technology, although most of the staff comes from other schools. The first draft of the new textbook is completed and will be used and criticized by high school physics teachers prior to publication in first-edition form. Much progress has been made on the teacher's manual to accompany this text. An editorial board has been selected for consideration of monographs, several of which are now being prepared, looking toward a total of perhaps 200. These monographs will supplement and amplify the text material, including applied uses of physics. New laboratory demonstration experiments, using equipment easily made with cheap materials, are being devised. Small units are being developed for students to construct apparatus and do physics experiments outside the classroom when desired. Film presentations of difficult and unusual experiments, e.g., the pressure of light, are being made and tried. Although it may be 2 years before the entire curriculum is ready to be considered by the general high school teaching group, encouraging and very stimulating progress has been made.

Extensive and continuing efforts have been made to secure the cooperation and assistance of the professional educational organizations in this work.

It should perhaps be emphasized that the National Science Foundation has supported only the initial research phase of this program. Action by appropriate individuals leading toward a new organization to handle the development, production, and distribution phase has already been initiated. Contacts have been made with the American Society of Textbook Publishers and others who might have a commercial interest in these activities.

Under the direction of the National Academy of Sciences-National Research Council, a careful study is being made at Michigan State University of introductory courses in biology offered by colleges and universities, and a sourcebook in biology for high school teachers is being prepared.

In the area of teaching aids, the Foundation is supporting studies of the possible use of motion picture films for instructing mathematics; of what we might glean that is original and creative in the teaching of mathematics in the secondary schools of other countries; and of laboratory procedures used in college courses in physics.

Other curricula studies supported by the Foundation during the year included: a conference on the undergraduate mathematics curriculum at Hunter College; a conference on the education of chemists at Johns Hopkins University; and a series of conferences in several Kentucky colleges to study the curricula for science instruction in elementary and secondary schools.

STUDENT PARTICIPATION PROJECTS

These projects are planned to increase interest in and understanding of science by students at all educational levels. Examples of the kinds of projects supported by the Foundation during the past year include the following:

1. *The Traveling Science Library program.*—Operated jointly with the American Association for the Advancement of Science, this program attempts to enrich the understanding of science by students at the small high schools by making available, on a loan basis, well-written books on science. During the 1956–57 school year, 25 libraries of 200 volumes each reached 100 of these high schools. This program is being increased to 54 libraries which are expected to visit 200 small high schools during the 1957–58 school year.

2. *The Traveling Science Demonstration Lecture Program.*—Supported jointly with the Atomic Energy Commission and administered by the Oak Ridge Institute of Nuclear Studies, it permitted 7 experienced high school teachers to be given 3 months of specialized training at Oak Ridge in subject matter and in the construction of simple apparatus to demonstrate scientific principles. Sets of such special demonstration equipment were then transported in station wagons to some 200 high schools all over the country. Lectures with demonstrations were given stressing the scientific principles involved in such subjects as solar radiation, atomic structure, nuclear reactors, space travel, and other subjects of scientific interest.

During the 1956–57 school year, more than 78,000 high school students heard the lectures and some 3,700 high school science teachers were reached by the program. In the 1957–58 school year, 10 science teachers (who were given special training during the preceding summer) will visit some 300 high schools to give similar lecture demonstrations.

3. *The Visiting Scientists program.*—This program enables eminent scientists to visit small colleges for periods of several days to talk with students and faculty about recent developments and career opportunities in the fields of the visitors' professional competence. Although the visiting scientists' program was begun in the field of mathematics, it has been extended to include chemistry, physics, and biology. A new feature—visits to some high schools—has now been added in the hope that contact with distinguished men of science will be of interest and inspiration to high school students. Reports from participating scientists and from officials of institutions visited affirm the success of the program.

4. *Films for Instructional Purposes.*—Three half-hour-length, color films on aspects of the International Geophysical Year are being prepared to provide an opportunity for developing interest in science and to acquaint young people with the meaning and scope of the IGY. The films will be made available to schools and colleges, and to television stations, as a contribution to science education.

5. *Other Student Participation Projects.*—Included are projects, such as the support of distribution of thousands of brochures describing career opportunities in the life sciences and designed to awaken student interest; studies of ways in which the Foundation can best provide assistance to State academies of science in furthering their interests in science education; studies designed to gather dependable information on the effects of science scholarship awards on student recipients; and continuation of support to Science Service to sustain its program of information for young people about the several fields of science and to encourage them to begin science projects through the Science Clubs of America.

TEACHER-TRAINING PROJECTS

These projects include all those special programs for teachers designed to improve science teaching with the exception of the previously mentioned institutes. Three significant examples will serve to indicate the scope and objectives of these projects.

1. Opportunities for secondary school teachers to pursue research studies in their fields of interest are severely limited because of inadequate library resources, lack of facilities, and absence of adequate supervision. To increase the effectiveness of teachers by broadening their knowledge of their fields of professional interest, the Foundation in fiscal year 1957 initiated two pilot programs to bring competent high school teachers into research laboratories of colleges and universities to undertake modest research studies in subjects of their own choosing.

2. The rapid development of computing machines and their usefulness in a wide variety of research investigations have created a demand for persons trained in the use and operation of computers. Although such training may be considered a proper responsibility of colleges and universities, there is a severe shortage of teachers competent to give instruction. The Foundation has provided support for a program of training for experienced mathematicians on the faculties of colleges and universities to prepare them to develop courses of instruction in the use and operation of modern computing machines.

3. Experimental programs were developed at both Duke and Purdue Universities for the training of retired military personnel to teach mathematics in colleges and secondary schools.[57]

B5. PSSC: First High School Curriculum

One of the more interesting new departures was the attempt to develop new curricula at the high school level. The Foundation staff had concluded that training teachers would be to little avail if they were constrained to use outmoded curricula. Improved curricula, it seemed, could best be obtained by enlisting outstanding research scientists—people who had keen insight into fundamentals by virtue of their continuing critical examination of physical models and concepts—to cooperate in the effort. The first such effort was begun with a grant, made on November 27, 1956 to the Massachusetts Institute of Technology to support the work of the Physical Science Study Committee (PSSC) under the direction of Dr. Jerrold R. Zacharias, a well known physicist.

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[57] Seventh Annual Report of the National Science Foundation. Fiscal Year 1957. Washington, U.S. Govt. Print. Off. [1958] p. 71-76.

The first goal of the PSSC would be to design a new high school physics curriculum. The first grant, to cover the "study phase", provided the relatively large sum of $303,000. The PSSC would eventually become a fairly permanent fixture of the NSF education budget as a result of the Foundation's feeling that there was a continuing need for the creation of new curricula and for the revision of older curricula. But it is interesting to note that NSF took considerable care in establishing review procedures and in approaching prospective publishers from the private sector. Both matters were to raise questions in later years.

C. SPUTNIK AND SOVIET COMPETITION: 1958 AND 1959

Fiscal year 1958 was nothing less than shocking. On October 4, 1957 the Soviet Union successfully launched and placed in orbit its Sputnik I, and thereby became a fearsome technological competitor of the United States. Until that time, even with Nicholas De Witt's book on Soviet manpower, it could be assumed that the implied technological threat of the USSR was several years from reality. Now that threat was immediate.

The Foundation's appropriation request for fiscal year 1958 was prepared in late calendar year 1956 for submission to the Congress in early 1957. The 1958 request was ambitious, as was the request for the previous year, and sought an increase of $25 million over the fiscal year 1957 appropriation of $40,000,000. The increase was justified by statements indicating: (1) The need for more basic research support; (2) the need for graduate student support; (3) the need for more training for high school science teachers; (4) the need to motivate more high school students to select science as a career; (5) the need for more modern research equipment in universities and colleges; and (6) the need for better means of disseminating research results. There was no new and expensive undertaking: the increase was primarily intended to expand existing programs.

Discussion in the House Appropriations hearings reflected a good deal of careful study by the Foundation of the education problem, and once again served to emphasize the Foundation's paradoxical situation in finding that it had to do something immediately to effect a great improvement in pre-college science education, and yet feeling that its methods had to be as indirect as possible.

> Dr. WATERMAN. Referring to the question you asked, Mr. Chairman, about the high-school situation, the disturbing thing insofar as the supply of teachers is concerned is that, as Dr. Kelly can tell you more in detail, of those science teachers who have been fully prepared each year for the last few years only half of them actually go into secondary-school teaching. You see, the demand for scientists enables them to find better jobs. Here is where we are really losing a great many teachers.
>
> Our program is, therefore, designed to encourage teachers in every possible way, help them out with the materials they need, such as the use of curriculum aids, the revision of elementary courses, and through our summer institutes.

> Mr. Thomas. That practice of "piracy" is a good old American institution, and I suppose the general good is served through it. So, you are going to have to contend with it and start making plans to do the next best thing.
>
> If you have good men, you are not going to keep them all in a high school. They are going someplace else. So you have to keep them coming in and prepare for the new life.
>
> Dr. Waterman. Our position in the Foundation is that if there is any way possible this should be done in the traditional way, by the local mechanisms—the communities, the school boards, and the States. If they are convinced that this problem is acute and needs attention, they can take the right steps most simply and, I think, most efficiently. But, my personal opinion is that we in the Foundation have to watch this, analyze the situation, and see that something is done—hopefully, that it can be done locally. That is the way, but it seems to me the Federal Government must be in a position to stand behind this whole thing and see that action is taken.
>
> Mr. Thomas. There is not anything too wrong with the average local school system that an increase in pay to those tecahers will not cure, is there, Doctor?
>
> Dr. Waterman. If we could achieve that, that would be a great step; yes, sir.
>
> Mr. Thomas. Well, the local communities and States have that job, and it should remain their job. However, my own judgment is that they are certainly a little behind, or away behind. The teachers are underpaid, and the school systems are not going to continue to attract the talent that they are entitled to, nor will they be able to hold them.[58]

And once again, Congressman Boland expressed the view that the stimulation of student interest in science begins at the elementary level, and that the Foundation would have to direct attention at that earlier stage of instruction:

> Mr. Boland. Dr. Bronk makes a significant point when he says the students say it is too hard, and they will not study. I think probably the responsibility is greater on the National Science Foundation than it is upon the Atomic Energy Commission to develop some sort of salesmanship in our teachers and in our schools.
>
> Dr. Bronk. That is right.
>
> Mr. Boland. I think you have to go beyond the high school. I think you should go into the grammar school and make mathematics attractive there.
>
> I think if you can build up a yearning, a love and desire and appreciation of mathematics not so much in high school but in grammar school, you would get somewhere.[59]

But in spite of a considerable interest by the Congress in NSF, the fiscal year 1958 appropriation was held at the $40 million level of 1957 and again included a statement earmarking $9,500,000 for the training of high school teacher of science and mathematics.

Then came Sputnik and an aura of overwhelming urgency, both in the Eisenhower Administration and in the Congress, to regain technological supremacy. Though President Eisenhower had been making a tremendous effort to balance the budget, this emerging power of the Soviet Union nullified his hopes. The National Science Foundation was allowed by the Bureau of the Budget to seek a supplemental appropriation for fiscal year 1958 of $9,900,000 to increase its activities in research and education. This included $2,107,000 for education, of which $1,415,000 was to be for institutes. The remaining $7,750,000 was to be for research. Congress did not quite agree, and appropriated a total of $8,750,000, with $2,367,000 earmarked for institutes. Once again the Foundation had more money for education than it wanted.

Of the 126 Summer Institutes held in 1958, five were for college teachers only; three, for both high school and college teachers; and the remaining 118 were for high school teachers only. Approximately 6,000 high school teachers and 300 college teachers were in attendance. The Academic Year Institutes were 19 in number and served about 925 teachers, many of whom were pursuing masters' or other graduate degrees. In addition, the In-Service Institutes Program served an approximately 3,000 participants, and was rapidly becoming one of the Foundation's most valuable programs.

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[58] U.S. Congress. House. Subcommittee of the Committee on Appropriations. Hearings. Independent offices appropriations for 1958. Washington, U.S. Govt. Print. Off. 1957. p. 1280-1281.

[59] Ibid., p. 1294.

Among NSF's other education programs there was constant change and experimentation, though the major components remained essentially as they were in fiscal year 1957. Total obligations in the education area totaled $20,398,468, with $5,602,120 in fellowships, $12,212,030 for institutes, and $835,372 for course content improvement.

This last effort had, by that time, become more definite in form and in its future plans. The Senate hearings on the supplemental appropriation contained the following description and justification:

> There has been widespread concern among scientists and educators alike over the failure of the instructional programs in the primary and secondary schools to arouse greater interest and understanding of the scientific disciplines. College teachers have often found entering students inadequately prepared to undertake work in the sciences at the college level. An important factor contributing to this situation is the subject-matter content of the science courses taught in the schools. There is general agreement that much of the science taught in the schools today does not reflect the current state of knowledge nor does it represent the best possible choice of material for instructional purposes.
>
> The Foundation has, therefore, given substantial support to a careful reexamination and revision of the subject matter taught in physics. These studies have been undertaken by eminent scientists working in cooperation with competent and experienced teachers, and a new and original approach to the teaching of physics in the secondary schools is being developed through their efforts.
>
> The new approach is not merely a revision of the traditional subject matter in high-school physics courses but represents a totally new and original instructional program in this discipline. The plan includes the preparation of new text material, new monographs on supplementary and reference material, the development of motion-picture films to teach subjects not easily handled in the classroom or laboratory, new experimental equipment and new laboratory exercises. In short, by drawing upon the knowledge and experience of the ablest physicists in this country as well as highly competent and experienced high-school teachers, a fundamentally new and imaginative course in physics is being developed. The new course will serve to bring understanding of the principles of science as well as the principles of physics to students. It will at the same time provide the college-bound students with a more adequate foundation for advanced study in this subject.
>
> The additional $400,000 requested for this program will be used to accelerate the timetable so that additional films under the revised physics curriculum can be made available in the spring semester of the 1958–59 academic year, and to begin a similar broad approach to basic revision of the high-school mathematics curriculum.
>
> Current plans of the physics curriculum revision grant (at the Massachusetts Institute of Technology) call for release of a total of sixty 10-minute films to illustrate portions of the curriculum. About 30 can be released by June 30 with present funds available ($300,000 from fiscal year 1958). In order that the remaining 30 can be released in the early spring of 1959, for use in the 1958–59 academic year an additional $200,000 will be required. If funds are not available the timetable will be delayed so that these films will not be completed and distributed until the fall of 1959.
>
> The remainder of the $400,000 requested will enable professsional societies in mathematics to begin a badly needed comprehensive revision of the high-school mathematics curriculum in much the same manner as the high-school physics curriculum revision is being revised. Availability of funds in fiscal year 1958 will permit the work to get underway at an earlier date than would otherwise be possible.[89]

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[89] U.S. Congress. Senate. Committee on Appropriations. Hearings. Second supplemental appropriation bill, 1958, 85th Congress, 2d session on H.R. 10881. Washington, U.S. Govt. Print. Off. 1958 p. 108, 109.

Clearly, curriculum development had now become a definite and large-scale activity at NSF.

C1. The National Defense Education Act: NSF Agrees To Avoid Involvement With Schools.

January, 1958 marked the formal beginning of a much deeper Federal involvement in pre-college education. In that month, President Eisenhower sent the Congress a message calling for new programs in education, with special attention toward education in science and engineering and a fivefold increase in the NSF education budget. These recommendations were given very serious consideration by the Congress, which responded with the National Defense Education Act of 1958. This legislation greatly enlarged the scope of activity of the Office of Education, and one of its many features was establishment of institutes for guidance counselors and foreign language teachers. These were broadened in 1964 to include teachers of English, geography, history, reading, plus teachers in certain specialized areas.

But this message, and the resulting legislation which replicated the NSF approach to improving pre-college education, had a far greater import for the Foundation. The President's recommendations, and the subsequent Congressional action, were predicated on an agreement between NSF and the Office of Education that the Foundation would deal exclusively with science and operate mainly through scientific societies and science departments of colleges and universities.

In contrast, the Office of Education would attempt to strengthen all areas of education, including science, by dealing primarily through state and local school systems.[61] This served to codify the NSF approach, perhaps to the relief of the Foundation, and to prevent its being pulled into the maelstrom of a more direct involvement with the institutions of pre-college education. The Foundation would thus limit its programs to those in which it dealt with pre-college education through colleges and universities, or through scientific societies, or possibly through individuals from the scientific community. But it did not deal with high schools, junior high schools, or elementary schools, in direct fashion. Nor would NSF have to concern itself to an unnecessary degree with obtaining approval for its activities from the Office of Education.

C2. NSF Puts 46.7% of Its Budget Into Education.

Fiscal year 1959 was remarkable in a number of ways. For one thing, it set something of a record in the relative amount of NSF resources devoted to the education area: *46.7 percent of NSF obligations in that year were through the Scientific Personnel and Education Division. It also marked the first year in which NSF supported an institute to teach one of its own Foundation-sponsored curricula.* And it saw the introduction of three new fellowship programs; two new institute programs, one of which was at the elementary level; six new programs in the special projects area; and one new program in the curriculum field. Sputnik had made it possible to consider what needed doing, rather than how much money could be obtained, in planning for education.

Even the appropriations hearings were somewhat remarkable. Though one or two National Science Board members customarily attended appropriations hearings, this time eleven members of the

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[61] Recounted in Krieghbaum and Rawson, *op cit*, p. 228, 229.

National Science Board attended the House hearings, and gave an unprecedented endorsement to NSF pre-college education efforts. The consensus appears to have been expressed by Samuel M. Nabrit, President of Texas Southern University, who said:

> In general, we cannot expect immediately the full return of what is being done in basic research and hence we cannot appraise its full value in terms of investment put in it at the time it is being carried on so these values are remote, but without them you would not have the applied technology that we speak of in any of the fields.
>
> Secondly, I should like to refer to the high-school program. Frankly, a year and a half ago I think many of us would have been somewhat reluctant to say a program as large as the one we now have in high-school teacher improvement was the most important phase of improvement in science.
>
> Today, after having had first hand experience and having followed through some of these institutes and seen the values that accrue to the participants, we think that this is one of the most worthwhile investments which has been made in the entire field of science, because in this way we can broaden the base of competence from which we can draw talent in the future.[62]

Clearly the Board had changed its mind since its objection to a greater proportionate emphasis on education at NSF during the hearings for the fiscal year 1957 appropriation. Another Board member, Sophie D. Aberle, Special Research Director of the University of New Mexico, gave an insight into how little was known about how to improve pre-college education:

> I will confine myself to secondary education. At least in New Mexico there is an opportunity today to do something we have never been able to do before and that is to take a new look at our high schools and our whole educational system and the need for a new look, not necessarily because this person made a mistake or that person didn't do something or something was left out, but they need a new look because science has moved so fast in the last few years that the children need to know more when they get to college than they ever knew before. We have to do something about new courses, new ways of teaching, new curriculums of all kinds, in elementary schools and high schools both.
>
> That means an enormous amount of experimentation, trying out new methods. What can the children learn more quickly? Are the methods we are using today the best? Can't these children who see so much television at home and know so much about science when they go to school, go faster than our first, second, third, and fourth grades now allow them to go?
>
> There is an awful lot of work which needs to be done to see how fast each group of children can be brought along in both the elementary and high school education.
>
> That means somebody has to study new methods in the curriculums, and the foundation has a very strong program on that. However, whenever you get into experimentation with people, children, the social sciences, you make a lot of mistakes. You cannot help it. If you knew what you were going to do it would not be an experiment.
>
> What I want to tell you is that we are going to do these experiments and we will do a lot of them and we will make mistakes and you have to be patient because you have to expect them.
>
> However, we will end up with something that is new and helpful to the bright children.[63]

Mr. Boland endorsed her statement shortly afterward in the hearing, making it clear once again that he thought NSF would have to extend its efforts to all levels of pre-college education:

> Mr. Boland. I have been saying in this committee, and also on the Atomic Energy Subcommittee on which I sit, that I think the problem reaches down below the high schools, into the elementary schools, where we don't have good teachers in mathematics and there is no love or yearning for the sciences.

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[62] U.S. Congress. House Subcommittee of the Committee on Appropriations. Hearings. Independent offices appropriations for 1959. 85th Congress, 2d session. Washington, U.S. Govt. Print. Office, 1958. p. 230.
[63] Ibid., p. 231.

> That is the place it should start. If you start it there you could build up a yearning for the sciences and mathematics, you could build up a desire to take those courses when they get to high school, instead of steering away from them as many high-school students do, if they are taught by good teachers, and they have to be good teachers.
>
> Should this agency make some sort of recommendation to pay mathematics and science teachers more so that we will have better teachers? There is no doubt about the fact it is a more difficult subject to teach than the ordinary subject taught in the elementary schools. If we can get the right teacher to do the job the students will go along.
>
> If we do that we are increasing this desire to learn as they get into high school. Perhaps we can develop a better student. If we do, if we do not pay him but supply a scholarship to enable him to go on to a school of higher education, perhaps that is one of the answers to it. I think what Dr. Bronk and the other distinguished people here today have said is true. This will not be done overnight. It will take years to do it. I agree with my chairman when he says he does not believe we are as far behind as some people would lead us to believe. Is this policy of Dr. Berkner, for whom I have great respect, the policy you need? Do you need a crash program, or do you have to rearrange your thinking on a national policy for science, and if you do, how are you going to do it? Will it be done by all these methods that the headline seekers are now talking about?
>
> What ought to be done? Are we proceeding in our kind of growth the way we ought to proceed, or perhaps we are not proceeding fast enough? Those are my observations.
>
> Mr. Thomas. He has more sense than any one man has use for having. Thank you, Mr. Boland. That is very much to the point.[64]

Judging by Chairman Thomas' response, it would seem that Mr. Boland spoke for the majority of the committee. Dr. Lloyd Berkner, who was a very highly regarded spokesman for science but who was not a member of the National Science Board, had recently published an article in the Atlantic Monthly stating that United States' science had received only intermittent attention, generally being neglected except when some National threat, such as Sputnik, required urgent attention. He had called for a national science policy to provide stability and proper long-term growth of science. The committee was concerned by Berkner's claim that science had been subordinated to strict economic concerns, and seems to have wanted to get both science and science education established on a proper footing. Thus the reference to Dr. Berkner was an indication that the committee had wanted to know what was really needed to ensure a healthy science community.

The fiscal year 1959 budget request was almost staggering in size compared to those of former years. In contrast to the fiscal year 1958 appropriation of $48.75 million, with about $20 million for Scientific Personnel and Education (SPE), NSF requested $140 million with almost $79 million for SPE in 1959.

Sputnik was not the sole cause for this large increase, for calendar 1958 was the year in which President Eisenhower appointed Dr. James R. Killian, Jr., president of the Massachusetts Institute of Technology, as his special assistant for science and technology and the year in which the Science Advisory Committee was moved from the Office of Defense Mobilization to the Office of the President. For the first time, NSF had a strong advocate to represent it in high-level discussions—particularly in the budgetmaking process. Thus it was asking considerably more support for SPE in fiscal year 1959 than the whole Foundation received in 1958.

The Congress responded very favorably, with an appropriation of $136 million for fiscal year 1959. Once again a sum was earmarked for programs for high school teachers, in this case $30,250,000—the amount the Foundation had requested. This is not to say that the appropriations process was uneventful, however. As was becoming customary, the House of Representatives initially passed an appropriation of only $115 million, whereas the Senate voted an appropriation of the full amount and the final figure was the result of a conference.

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[64] Ibid, p. 251, 252.

C3. NSF Institutes Begin Curriculum Instruction.

The record of the fiscal year 1959 appropriations hearings in the House of Representatives contains yet another indication of the committee's active interest in the Foundation's pre-college education efforts. NSF proposed to escalate its Course Content Improvement Program from about $600,000 (estimated at the time of the hearings-January 21, 1958) in fiscal year 1958 to $6,000,000 in fiscal year 1959. The intent was to add a number of other curricula to the original development effort in physics. The subcommittee chairman, Mr. Thomas, became concerned that such a large investment in the development of new curricula might be to no avail unless some means were found to get school boards to adopt them:

> Dr. KELLY. This program I described in physics has resulted in a draft of a new text in physics, monographs to go along with that text describing some of the applications, a series of films of 20 minutes each which will describe some of the experiments which are difficult.
>
> Mr. THOMAS. You referred to the text yesterday and again today. Who wrote the text? A text is only a text when it is adopted, in my language, by States, universities, et cetera. What assurance do you have this will be adopted?
>
> Dr. WATERMAN. This is a draft text to be tried out at the present time.[63]

Perhaps in consequence of this interest, NSF expanded a small experiment it had made during the 1957-58 academic year to offer teachers instruction in the new curriculum through an in-service institute; that is, an institute during the school year which teachers attend in non-working hours. This first in-service attempt is reputed to have been conducted by Dr. Noel C. Little at Bowdoin College, though there may have been additional pilot studies. But work began in earnest in the summer of 1958, when five summer institutes offered instruction in the content and requisite teaching methods for the PSSC physics curriculum.

The effort to teach the new NSF-sponsored curriculum also seems to have been a response to increasing pressure from teachers and schools. Everyone seemed suddenly to become aware of the poor science instruction offered in high schools and wanted to do something about it. However, the PSSC physics curriculum, as with many later NSF-sponsored curricula, was set up in such a way that the student learned by doing experiments, by making his or her own observations, and by generalizing on this first-hand experience. This curriculum required that the teacher be able to teach students how to operate as scientists in the classroom. In the case of this first PSSC course the students were to operate as physicists. Since very few high school teachers knew physics, much less how to operate and think as a physicist must (even on a very elementary level), the National Science Foundation found that it had to get involved in teaching teachers how to use modern science curricula.

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[63] Ibid, p. 431.

This program, generally referred to as *curriculum implementation*, grew to become a major component of the NSF education effort in later years. It would also come to be a focus for debate on the issue of whether pre-college curriculum instruction was an appropriate activity for the Federal Government; the question being whether such activities would lead to undue Federal influence in local school and community affairs and whether the new curricula contained unacceptable material. But in the post-Sputnik era of 1958 and 1959 it seemed a matter of national urgency to improve high school science education as rapidly as possible. Curriculum instruction undoubtedly had a very high priority in many minds, and apparently had considerable congressional support as well.

The National Science Foundation capitalized on the newfound support in the Administration and in the Congress by seeking to introduce 16 new programs in the Scientific Personnel and Education Directorate. Those new programs relating to pre-college education, requested in Fiscal Year 1959, were as follows. Descriptive text is from the NSF budget justification for fiscal year 1959 and from the 9th Annual Report of the NSF:

I. Fellowship Program

A. SUMMER FELLOWSHIPS FOR HIGH SCHOOL SCIENCE AND MATHEMATICS TEACHERS

This new program is needed to round out the Foundation's efforts in improving secondary school science and mathematics instruction. Summer institutes offer preplanned training programs for groups of people and are, for many teachers, an ideal form of further study. Summer fellowships, on the other hand, are intended for those teachers who for various reasons would profit from a completely individualized form of study. Some, however, may wish to combine study at an institute with additional individualized study. The summer institutes and fellowships would be flexible on this point.

B. PRESERVICE TEACHER TRAINING PROGRAM

There are now in the labor force many able persons who, after high school graduation, did not enter upon college-level studies either for financial or motivational reasons. Provided the necessary financial support were now available, many of them would seize upon the opportunity to undertake studies to become secondary school science and mathematics teachers. Trainees in this program would be drawn from this pool of persons, and selected on a nationally competitive basis but cooperatively with the grantee institutions.

Special training programs for them would be developed at specially chosen academic institutions. At each institution cooperative planning among educators, scientists, and mathematicians would result in a new and specially constructed curriculum. Trainees would undergo training in two phases.

The first would consist of 2 calendar years of study (academic years 1959–60 and 1960–61) interrupted by only a short summer vacation (c.f., the Navy V–12 program during World War II). This would be the equivalent of 3 normal academic years of study. Phase II would consist of 3 additional full summers of study (1962, 1963, and 1964) interspersed with 3 academic years of on-the-job teaching in high school on provisional certification. At the end of the third summer each trainee would have had the equivalent of a full 4 academic years of study, would be eligible for a baccalaureate degree and teaching certificate and would already have taught 3 years (by the fall of 1964).

II. Institutes Program

A. SUMMER INSTITUTES FOR ELEMENTARY SCHOOL SUPERVISORS

This program was developed on an experimental basis in 1959. These experimental institutes are specifically designed to give key teachers and supervisory personnel in elementary schools an opportunity to increase their knowledge of the sciences and mathematics, in order that science and mathematics can be taught more effectively to students in the elementary schools.

This experimental program of 12 institutes provided training for 515 teachers and elementary school science supervisors.

B. IN-SERVICE INSTITUTES FOR ELEMENTARY SCHOOL TEACHERS

A very limited program of in-service institutes for elementary school teachers and supervisors of mathematics and science will be supported on an experimental basis during the 1959–60 school year. Eleven grants were made to 11 different institutions in 10 States and Puerto Rico. About 350 elementary school teachers and supervisors will have an opportunity for further study under this program.

III. SPECIAL PROJECTS IN SCIENCE EDUCATION

A. COOPERATIVE COLLEGE-SCHOOL PROGRAM

This program would be administered through grants to universities which, in turn, would carefully select secondary schools in their areas and then cooperate with these schools in the planning and provision of the most effective instructional programs possible for the high-ability students. Schools would be encouraged to use their most outstanding teachers in this program, and every effort would be made to encourage science and mathematics teachers in the program to gain still greater mastery over their subjects through summer work or study at appropriate universities.

B. LABORATORY TRAINING OF TEACHERS

(To instruct teachers on classroom laboratory technique)

C. TEACHER SELF-IMPROVEMENT PROGRAM

(Actually piloted in fiscal year 1958. Books, films, and other material is made available to teachers for self-instruction.)

D. SECONDARY SCHOOL STUDENT-TRAINING PROGRAMS

This is a new program designed to encourage the scientific interests of high-school students of high ability by providing them an opportunity to associate with a college science program. This will be accomplished by providing support for summer institutes for such high-school students in science and mathematics at colleges and universities.

IV. COURSE CONTENT STUDIES AND DEVELOPMENT

A. ELEMENTARY AND JUNIOR HIGH SCHOOL SCIENCE

1. *Science and Mathematics in Elementary Schools.*—Throughout the country, elementary schools may soon teach science in every grade, along with mathematics. The problem is to identify significant content; to determine at what levels particular concepts can be grasped (taking variations in student backgrounds and abilities into account); and to develop written materials, apparatus, and other aids for pupils and teachers. Teachers' manuals and similar materials are particularly important, for many elementary school teachers have had little preparation in science. In this field, projects are still exploratory and experimental. Among them are work by mathematicians and teachers at Stanford University on adding geometry and other topics in grades 1–6, investigation by a group at the University of California at Berkeley on science for these grades, and development of teaching materials in geology under the sponsorship of the American Geological Institute and the University of Minnesota.

2. *Mathematics.*—The School Mathematics Study Group was organized in mid-1958 to carry out an extensive program to improve mathematics teaching in elementary and secondary schools. Many eminent mathematicians and accomplished teachers are engaged in this project, which is sponsored by Yale University and directed by Prof. E. G. Begle.

Not all of these proposed programs were actually implemented. The Pre-service Teacher Training Program does not appear to have survived for long, if in fact it was even tried. The Special Projects in Education Program was soon re-structured into broad categories: Science Education for Students, Science Education for Teachers, and Public Understanding of Science. While grants may have been made to support projects that might have fit the various specific program objectives outlined in the budget submission for fiscal year 1959, the Foundation came to prefer these less specific titles which seemed to promise greater flexibility.

In addition to the general effort mentioned above to revise mathematics curricula at all levels, the Foundation maintained its curriculum program in physics, and added studies in chemistry and the life sciences. The following reports were included in the Ninth Annual Report:

> *Physics.*—High school physics is the subject of the pioneering comprehensive study. By September 1960, revised instructional materials will be available through commercial channels for all schools wishing to adopt the course. The result of 4 years of effort by several score of the Nation's top physicists, as well as several hundred teachers who participated in developing the material and testing preliminary versions, the course focuses upon the great ideas of physics and provides insights into the way these ideas have developed. A textbook, laboratory guide, a special kit of apparatus, films presenting major experiments not readily conducted in the classroom, examinations, a teachers' guide, and supplementary books on special topics have been fashioned into a carefully articulated learning experience. This course represents a new approach to high school physics and, for the first time in many years, brings the indispensable range and depth of knowledge of a number of eminent scientists into the development of as secondary school curriculum. The Physical Science Study Committee, of which Prof. J. R. Zacharias is chairman, under the sponsorship of the Massachusetts Institute of Technology and Educational Services, Inc., has made educational history with the aid of grants from NSF and from other groups.
>
> *Chemistry.*—Several approaches may prove desirable in high school chemistry. Conferences in 1957 and 1958 led to a summer writing conference at Reed College in 1959, where research leaders and college and secondary school teachers prepared a preliminary textbook and demonstration and laboratory experiments for a course using chemical bonds as the central theme. Meanwhile an interim committee of distinguished chemists, sponsored by Ohio State University, is preparing plans for a chemistry project comparable to that in physics.
>
> *Life Sciences.*—In the life sciences a large group of eminent biologists and teachers have initiated the Biological Sciences Curriculum Study (BSCS) under the chairmanship of Dr. H. Bently Glass of Johns Hopkins University and the sponsorship of the American Institute of Biological Sciences. It is the intention of the BSCS, first, to develop a new high school course in biology, and later to contribute to the improvement of biological instruction at other levels.
>
> Support has also been granted to the National Academy of Sciences for completing the revision of a sourcebook of laboratory and field studies for high school biology, the preliminary edition of which has received widespread commendation.

D. SUMMARY 1950–1959

Fiscal year 1959 marked the end of an era in which the National Science Foundation developed its educational programs and philosophy. When the Foundation began operations, it limited its attention to graduate training in spite of the many statements in *Science—the Endless Frontier* and elsewhere that the high schools were the bottleneck in science education. In the first few years the advice of the staff and of consultants regarding the need to improve secondary school science education was ignored. Nor was there anyone on the National Science Board who might have been expected to articulate the problems in secondary school education. In fact, the Foundation largely ignored the entire area until the scientific societies, and the President of the United States, and the United States Congress each made it clear that NSF would have to take action.

Once started on the road to helping pre-college education, the Foundation began to exhibit less timidity, and occasionally some real initiative, in instituting programs to treat important aspects of the problem. It responded favorably to the MIT-Zacharias proposal to initiate curriculum revision along a broad front, and began to play an unusually useful role in getting articulate and eminent scientists from the research community involved in developing pre-college curricula. As the new decade of the 1960's approached, the general form of the NSF educational programs became essentially complete. The coming years would be much less tumultuous than the later years of the 1950's, in which so much had to be accomplished so quickly.

III. THE MIDDLE YEARS: STABILITY AND GROWTH, 1960–1965

In contrast to the years of experiment and development from 1950 through 1959, in which the National Science Foundation discovered its full range of responsibility in science education, the years immediately following offered stability and growth. There eventually came a point at which the Congress began to be concerned about the rate of growth of the Foundation's budget, including the budget for education. But such concerns did not appear until around the mid-decade of the 1960's, and even then the NSF's pre-college education programs seemed to maintain the sympathetic interest of the Congress.

A. FISCAL YEAR 1960—CONTINUED CONGRESSIONAL INTEREST IN PRE-COLLEGE EDUCATION

Negotiations for the fiscal year 1960 budget were exceptionally smooth, bearing in mind that the National Science Foundation never has enjoyed unquestioned allegiance in Congress for any great length of time. In the hearings for fiscal year 1960, which took place in February 1959, some members of the House Committee on Appropriations seemed to think that the Foundation's efforts to improve high school education were not sufficiently direct: NSF did not work with the school boards which would necessarily be the instruments for improvement in the schools.

A1. "We do not deal with the State school authorities"

Mr. Jonas opened the discussion in the hearings with a question about how the general status of high school science education was to be improved, apart from the special instruction for gifted science students:

Mr. JONAS. It seems to me that your principal emphasis is on helping students who have already displayed superior qualities in this field. Are you doing anything to encourage the strengthening of the curriculum for all high schools and secondary school students? That cannot be done by you alone but only through the cooperation of the State school authorities.

Dr. WATERMAN. Yes. We do not deal with the State school authorities because that is in the jurisdiction of the Office of Education.

Mr. JONAS. You mean you do not deal with the State boards at all?

Dr. WATERMAN. No, we deal directly with the State institutions, and through them make grants for the institute, and then the institution invites applications from teachers to come there to attend the institute.

Mr. JONAS. I am not thinking about improving the ability of the teachers, which I think can stand some improvement all right, but I am thinking in terms of strengthening the regular high school curriculum.

Dr. WATERMAN. We feel this is properly the function of the Office of Education.

Mr. JONAS. Do you not think you have authority to move in that field?

Dr. WATERMAN. Only in science. Of course, we have said a great deal about this. However, in many subjects, our Advisory Committees and our Board are working with the Office of Education. There is a planning group on this at the present time. I know the National Academy of Sciences is interested, too.

Dr. KELLY. May I comment on that too?

Mr. JONAS. Yes, sir.

Dr. Kelly. We think our role is, first, to get the leading scholars in a particular field to work with a group of teachers in developing a program or curriculum. We have a list of principles that serve in initiating such a study, and if you like, I would like to read a few of them to answer the question.

Mr. Jonas. By all means, go ahead.

Dr. Kelly. Thank you. The initiative for a study should arise from a conviction on the part of responsible scientists of high professional stature and of competent and experienced teachers at all appropriate levels that a serious educational problem exists in a scientific discipline or in a group of disciplines.

I would also like to read you gentlemen where we put our limitation in: The Foundation must have assurance that scientists distinguished as teachers or as investigators in the disciplines concerned will be willing to give leadership, time, and effort to the proposed study. The Foundation's interest in these projects is to support studies of course content as a kind of research enterprise, including reasonable trial and testing in schools, but Foundation funds must not be used to promote the general acceptance of the new courses or materials.

That is if these groups of scholars do develop material which is good itself, it should speak for itself. We do not want to impose these on any State, but we believe if it is good enough, it will develop interest. It is already beginning to work that way.

Mr. Jonas. Is that not a rather restricted interpretation of the authority conferred on the Foundation by the act itself? I think it is far broader than you have interpreted it. I do not see anything in the act, as I recall it, that would prevent your working with State school authorities in an effort to strengthen local curriculums.

Dr. Kelly. No, sir.

Dr. Waterman. That is the Office of Education.

Mr. Jonas. Let us see that act. The principal function now is granting scholarships.

At this point Mr. Thomas interrupted with a short inquiry about the budget. Then the discussion continued:

Mr. Thomas. Excuse me, Mr. Jonas. You wanted to read the act. Go ahead.

Mr. Jonas. I wanted to cite subparagraph 6, section 3, which represents one of your directives to evaluate scientific research programs undertaken by agencies of the Federal Government and to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups.

Dr. Waterman. This is research, you see. We have in section 3(b) in exercising authority, and that is the functions referred to in subsection a, it shall be the job of the Foundation to strengthen basic research, and study in the sciences, including independent research, and so forth: and in general we are regarding this as a very important policy for the country right now, and our policy is very clear in forwarding research.

Mr. Jonas. You do not think you have any authority to work with State school boards now?

Dr. Waterman. I think it would be very confusing since the Office of Education has the experience and the authority too. We are glad to support them. For example, the subject of scholarships was mentioned a while ago; and, as I said, we have thought this would not be wise, but we have supported the Office of Education in the attempt to get a scholarship program in general, not just science scholarships.

Mr. Jonas. I guess I had a misconception of the authority or the basic responsibility placed on you. I was thinking the act charged you with the responsibility of trying to develop a national policy along the line of scientific education, and that would include efforts to do just what I have indicated I think needs to be done at the present time, and that is to strengthen the base of the curriculum that is used in secondary and high schools.

Frankly, it is a surprising thing to me that you need to devote so much attention to efforts to strengthen curriculums in colleges.

Dr. Waterman. It is done by colleges.

Dr. Kelly. We are sensitive on this point you bring up, Mr. Jonas. We think the attack should be to encourage the local and State colleges and universities to take an active interest in improving the quality of education at the high school level.

Mr. Jonas. Do they need stimulation; that is, the colleges themselves?

Dr. Waterman. Yes.

Dr. Kelly. Yes. That is what we do through our summer institutes. We do encourage them to set up such summer programs in science and mathematics, especially designed for the teachers. I know that there is a relationship between this and the State departments of education; but we believe that the responsibility for developing coordination and cooperation with local and State departments of education should be with the local people and the local colleges and universities that plan courses.

Dr. Waterman. One misconception probably is that while we make grants to colleges and universities, they are aimed at improving the level in secondary and elementary schools; so if you look behind these titles, you will see that a major part of it all is directed toward an improvement of the content, bringing up to date the content of the science courses and methods of teaching.

Mr. Thomas. Page 260 has a chart. Is that in colleges?

Dr. Waterman. Yes; those are undergraduate courses.

Mr. Jonas. I yield

Mr. Ostertag. Mr Chairman, may I ask a question at this point?

Mr. Thomas. Certainly.

Mr. Ostertag. You were wondering in connection with the National Education Act where this program is associated. Is it directly associated with that in any way or indirectly associated?

Dr. Waterman. We coordinate the program with the Office of Education.

Mr. Thomas. I think they are hard to express. I think Mr. Jonas' point is well taken. The language of the act is broad enough to do practically anything you want to do. Now, it is a question of what you do in connection with the Department of Health, Education, and Welfare, and others, where you have overlapping.

If you did not have the Department of Health, Education, and Welfare, you could do anything you want to under it. Is that not a reasonably accurate statement?

Dr. Waterman. I would suppose so.

Mr. Jonas. That section 3(a)(1) is open-ended, I think.

Dr. Waterman. Yes, sir.

Mr. Jonas. I do not see why you would have any difficulty doing what I have suggested under that very first authority. I would like to read it into the record, and then I will not have anything more to say: "To develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences."[66]

Thus it would seem that NSF's refusal to take direct action to bring about an improvement in high school science education may have constituted a problem in the Foundation's effective relations with certain Members of the Congress. On the other hand, other Members felt otherwise and expressed concern about closer Federal-school relationships. Mr. Thomas was of that opinion.

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[66] U.S. Congress. House. A Subcommittee of the Committee on Appropriations. Hearings, Independent Offices Approriations for 1960. Washington, U.S. Govt. Print. Off. 1959. pp. 573-576.

A2. The fiscal year 1960 institutes program

The budget justification for Fiscal Year 1960 included the following recapitulation of the summer institutes activity and methodology:

Fiscal year and type	Number of institutes	Number of NSF stipend holders	Support provided by NSF
1953: College	2	42	$21,200
1954:			
High school	1	26	10,600
College	3	71	40,500
1955:			
High school	4	126	59,000
High school and college	2	(1)	(1)
College	5	173	75,000
1956:			
High school	13	750	380,000
High school and college	5	(1)	(1)
College	7	450	235,000
1957:			
High school	87	4,800	5,055,000
High school and college	4	(1)	(1)
College	5	300	278,000
1958:			
High school	120	6,000	6,400,000
College	5	300	285,000
1959:[2]			
High school	320	16,000	19,750,000
College institute	35	1,400	2,200,000
College conferences	20	800	
Technical institutes	2	80	100,000
Elementary	10	450	500,000
1960:[2]			
High school	320	16,000	19,750,000
College institute	35	1,400	2,200,000
College conferences	20	800	
Technical institutes	2	80	100,000
Elementary	10	450	500,000

[1] Included in figures for high school and college.
[2] Estimated.

From two in 1953, the number of summer institutes sponsored by the Foundation had grown to 125 in 1958, and approaches 400 in 1959. Some 50,000 applications were received for the 6,300 available stipends in the summer of 1958. Nearly 19,000 teachers will be enrolled in the 1959 summer institutes.

Summer institutes have proved to be remarkably successful in their immediate, fundamental purpose: improving the mastery of subject matter by science and mathematics teachers, in order that their classes can be better taught. They are also proving to be effective in encouraging colleges and universities to provide programs suited to the needs of teachers. Some new degree programs designed for teachers have been established.

* * * * * * *

For the summer institutes, the Foundation provides funds for participant support, and instructional management costs for the institutes.

The support given each stipend holder includes: a stipend of not more than $75 per week, a dependency allowance of not more than $15 per week for each dependent up to a maximum of four, and a travel allowance at the rate of 4 cents per mile for one trip from home to institute and return, up to a maximum of $80. In addition the Foundation pays tuition and fees for the stipend holders, plus instructional and management costs of the institute to the amount that these exceed the amount granted for tuition and fees.

Institute enrollment is not limited to stipend holders. Other individuals, acceptable to the institute staff, can be admitted so long as their number is not so great as to diminish the effectiveness of the institute.

A typical summer institute has about 50 stipend holders and several nonstipend holders. It may offer work in a single science or mathematics area, or it may include offerings in several subjects. Prominent visiting scientists supplement the local staff. The institute ordinarily provides seminars, lectures, etc., in addition to specially designed courses. Also, it ordinarily provides considerable opportunity for informal discussions between registrants, and between registrants and staff,

> both in and out of classrooms. These discussions and group learning are encouraged through housing registrants (and staff) in an area set aside for them, through group meals, and through informal activities such as field trips, special lectures, etc. The benefit is greatest when the registrant group is coherent, having similar problems and enrollment in a common program, but come from different regions or sections of the country, so that developments in each section can become available to others.
>
> The first summer institutes supported by the National Science Foundation were for college teachers. Under congressional directives, the preponderant number since 1956 have been for high school teachers.[67]

The In-Service Institutes were discussed as follows:

> To the host institutions conducting in-service institutes, the Foundation contributes support toward institute operational costs. Teacher participants receive neither stipends nor dependency allowance, but do receive travel allowances at the rate of 7 cents per mile for necessary travel to participate in the institute, and tuition is paid for them. Beginning in fiscal year 1960, it is proposed to allow each participant a nominal allowance of about $10 for purchase of textbooks. (Such an allowance for textbooks was strongly recommended by 1958–59 in-service institute directors.) In fiscal year 1959 (school year 1959–60) the Foundation plans to provide support for some 200 in-service institutes for high school teachers. It is expected that about 7,500 teachers will enroll, at a cost to the Foundation of $1,500,000. It is estimated that fiscal year 1960 will continue at the same level as fiscal year 1959.
>
> The National Science Foundation inservice program was begun with two institutes for high school teachers during the spring semester of 1957. During the 1958–59 schoolyear, some 3,000 high school teachers are receiving training in 85 inservice institutes.
>
> Some colleges and universities are proposing a combination of inservice and summer institutes, with a continuing body of participants. Through full-time summer enrollment added to the part-time school year participation, progress toward an advanced degree can be hastened.[68]

Academic year institutes were somewhat in the form of sabbatical fellowships with specially designed curricula and with some special courses not normally offered by the host institutions.

13. Congress Expresses its Support

Suffice it to say that, of all the programs offered by the Foundation, the institutes were the congressional favorites. The congressional mandate of a minimum allocation for the training of high school teachers of mathematics and science became a regular feature of the NSF appropriation, as if to insure that the research-oriented managers of the Foundation not be able to place other interests ahead of those of the high schools. And as time passed, the institutes came to be regarded as a constructive way to promote greater geographic distribution of NSF money.

The report of the House Committee on Appropriations reflected these sentiments:

> For several years the Committee has been very interested in the programs for the supplementary education of high school science and mathematics teachers and on several occasions has provided funds in excess of the budget estimate for their expansion. Their value is now well established and the bill contains $33,050,000 as recommended in the budget estimates for continuing the present high level of these programs in 1960.[69]

As in other years, the House attempted to trim the proposed budget while the Senate sought a restoration of funds. Of the $160,300,000 proposed by the Administration, the House reported an appropriation of $143,273,000 with only a reduction of about $150,000 in the total

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[67] Ibid, p. 589, 590.

[68] Ibid, p. 595.

[69] U.S. Congress. House. House Report 350. 86th Congress, 1st session.

$66,599,000 requested for the education programs. This final total appropriation was for $152,773,000, with the education programs' budget essentially as proposed.

B. FISCAL YEAR 1961—INCREASING QUESTIONS FROM CONGRESS ABOUT MANAGEMENT OF CURRICULUM DEVELOPMENT

In the hearings of the House Committee on Appropriations on the fiscal year 1961 budget, the subject of curriculum improvement received a good deal of attention. The committee was sympathetic to the $6,000,000 being requested for curriculum improvement, but wanted to see substantive signs of progress. It apparently seemed to Mr. Thomas that curriculum improvement might become a never-ending and expensive project, and he questioned the NSF extensively about details—albeit saying that he was trying to help the Foundation justify its request, which was to be spent as shown in the table:

NSF CURRICULUM IMPROVEMENT

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Elementary and junior high schools	$558, 910	$500, 000	$750, 000	+$250, 000
Secondary schools	3, 519, 000	3, 000, 000	3, 000, 000	0
Colleges and universities	210, 950	1, 000, 000	1, 000, 000	0
Subtotal	4, 288, 860	4, 500, 000	4, 750, 000	+250, 000
Supplementary teaching aids	1, 741, 465	1, 500, 000	1, 250, 000	−250, 000
Program total	6, 030, 325	6, 000, 000	6, 000, 000	0

Mr. THOMAS. Your request for 1961 is in the amount of $6 million, the same amount as you had last year.

What are you doing in that field? Can you put your finger on some concrete, good results?

Dr. DEES. Mr. Chairman, this is an area where we have a really new, burgeoning and already-proven set of ideas coming forward.

Mr. THOMAS. You have four big programs. You have the elementary and junior high schools, where you are requesting the sum of $750,000; this shows an increase of $250,000 over 1960.

Then you have your secondary schools wherein you are requesting $3 million, the same amount as last year; you have your colleges and universities wherein you are requesting the same amount as last year, $1 million; and then you have supplementary teaching aids wherein you are requesting $1.25 million, which represents a decrease of $250,000.

Dr. KELLY. This is the program we discussed a little bit yesterday, and Dr. Stratton from MIT spoke so highly of. The program, I think, is one that we can be most proud of; this has resulted in the top leaders of science, Nobel Prize winners in some cases, working with high school teachers on the course content material for the high schools.[70]

But while Mr. Thomas was impressed with the Course Content Improvement Program and with the people who were involved, his basic concern seems to have been the uncertainty about the duration and about the cost of the entire effort:

Mr. THOMAS. This is a recurring item. You started it in 1959 and you had an appropriation in 1960 and you now want one in 1961.

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[70] U.S. Congress. House. A Subcommittee of the Committee on Appropriations. Hearings. Independent Offices Appropriations for 1961. Washington, U.S. Govt. Print. Off. 1961. p. 142, 143.

How long is it going to take to rewrite these textbooks? In brief, this is a rewriting job; is it not? In my opinion it is the best part of your program which totals $18 million or $20 million.

We are trying to help you to justify it.

Dr. **Kelly**. We have experience as to the probable cost of each one of the other studies. The total for the Physical Science Study Committee was approximately $5 million.

Mr. **Thomas**. You have already gotten $6 million for it in 1959 and 1960.

Dr. **Kelly**. But we have three other fields plus the college and plus the elementary school level.

Mr. **Thomas**. How long is this program going to continue before it is complete?

Dr. **Waterman**. The physical-science study is beginning to wind up. The others are only beginning. However, we expect the physics one will be completed before long.

Mr. **Thomas**. You estimate a $5 million cost. You have had $12 million already appropriated for this purpose.

Dr. **Dees**. $5 million for physics at the high-school level only, Mr. Chairman.

Mr. **Thomas**. What is it going to cost at the high-school level to complete your program for physics, chemistry, math, and all the rest?

Dr. **Waterman**. Chemistry is just beginning, and biology is underway.

Mr. **Thomas**. Please give us a preview, and how long it is going to take to do the job.

Dr. **Dees**. It is very likely that at the senior-high-school level, that is, grades 9 through 12, that it will take on the order of $20 million to $25 million to do the same quality of job across the board in biology, physics, math, and chemistry that is already being accomplished in the physics area.

Mr. **Thomas**. $25 million for one subject?

Dr. **Dees**. For these four subjects.

Mr. **Thomas**. Physics, chemistry, biology, and math?

Dr. **Dees**. All of the high-school sciences and mathematics.

Mr. **Thomas**. How much have you had appropriated for that purpose to date?

Dr. **Dees**. Of the order of $13 million, because prior to 1959 we had only a very small amount for this.

Mr. **Thomas**. What about the college-level problem? Are you going to attack the textbook problem at the college level also in the same fields?

Dr. **Dees**. Yes; but it is very likely that this will be approached in a necessarily different way because whereas it is possible to prepare——

Mr. **Thomas**. Are you spending any of your $12 million that you have in hand now for fiscal 1959 and 1960 for college-work improvement?

Dr. **Dees**. Yes, sir.

Mr. **Thomas**. They are going hand in hand—high school and college?

Dr. **Dees**. Yes, sir.

Mr. **Thomas**. What will your course improvement at the college level in textbooks cost? You gave a figure of $25 million for the high schools. What will the college work cost?

Dr. **Dees**. The college problem, as you know, is very much more complex because it includes other fields as, for example, engineering.

Mr. **Thomas**. Doctor, we understand that, or at least we can take your word for it.

What about the dollar mark?

Dr. **Dees**. Frankly, Mr. Chairman, we do not at this point in time have a firm figure, because this is an area—the college level—that we are only beginning to tackle in a substantive or substantial way. If you wish an educated guess, the cost would be something of the order of $30 million to $40 million over a period of a number of years, meaning 4 or 5 years, more or less.[70a]

In the end, Mr. Thomas seemed to accept the uncertainties about the cost. However, he did express the view that the project was taking too long:

Mr. **Thomas**. Gentlemen, if this business is as important as we all think it is, should not drag on over a period of 10 or 15 years and be that indefinite.

Let us get on top of it and see if we cannot get it behind us.

If it is as valuable as we think it is, why waste all this time dragging it out? [71]

[70a] Ibid, p. 145, 146.

[71] Ibid, p. 148.

On the other hand, Mr. Jonas' concern was about the business arrangements entailed in publication and distribution of the PSSC material:

> Mr. Jonas. Who makes the profit on publishing the text material?
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> Dr. Dees. There was a series of bids from the various publishing houses to the Physical Science Study Committee in determining who would publish the basic textbook, which is to be published in the next 3 or 4 months. D. C. Heath & Co. will publish the book and the royalties from the sales will revert to the nonprofit group, Educational Services, Inc. (which was set up more or less specifically for this purpose), and the disposition of these royalties is to be determined by the Foundation in consultation with ESI.
>
> Mr. Yates. Why should not that money go to the Government?
>
> Dr. Dees. This is one of the possibilities. The point is that, although this is an important contribution to high school physics, there will not be large moneys resulting from the royalties. There will be the need for continual revision of this material, another of the possibilities is that—rather than continuing to seek separate appropriations for that kind of revision—if the royalties are adequate, they could be used for this purpose.[72]

Taken in its entirety, the PSSC curriculum presented a great many problems. It was a very new pedagogical approach, using films as well as text material. It was proving expensive to develop (about $4 million by the beginning of 1960), it needed extensive testing before it could be evaluated properly, and separate private facilities had to be established to distribute the text, the films, and the laboratory apparatus. These problems were harbingers of NSF's experiences in later curriculum projects.

In spite of these difficulties, the NSF budget continued to increase steadily. Though the House recommended only $160 million of a $190 million request for fiscal year 1961—approximately a constant level of effort—the Senate endorsed the full amount and the conference committee reported a figure midway between the two. The NSF budget for Scientific Personnel and Education stayed constant, with no Congressional stipulation as to institute support that year.

C. FISCAL YEAR 1962—CONTINUED CONGRESSIONAL CONCERN ABOUT CURRICULUM DEVELOPMENT MANAGEMENT

Fiscal year 1962 marked another strong advance for NSF's Division of Scientific Personnel and Education. Obligations were 18 percent larger than the previous year, an increase of about $12 million over fiscal year 1961. However, the largest increases went to other Foundation programs, with the total appropriation rising to about $263 million from about $176 million in fiscal year 1961.

As usual, the House Committee on Appropriations exercised its authority to examine financial matters rather carefully. One of the main topics of interest in the hearings that year was the cost of development and publishing arrangements for the new curricula being developed.

C1. Inquiry into Cost of Curriculum Development

The NSF was requesting an estimated increase of about $3.7 million to a total figure of $10 million for curriculum development. Members of the committee were concerned that curriculum development projects seemed to be never-ending; seemed to be incredibly expensive; and seemed to put NSF in a rather unusual position of transferring entirely a government-developed product to the civilian sector. Chairman Thomas clearly felt that these points deserved careful examination, and he pursued the matter directly:

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[72] Ibid, p. 149.

> Mr. THOMAS. Let us take up course content, pages 288 and 289. This is a tremendous increase of $3.8 million to $10 million. This deals with your elementary and secondary schools, and then the colleges and supplemental training aids. This is perhaps one of your most important programs.
>
> Give us the status of this program. The language on this page is a little vague. The amount requested for fiscal year 1962 represents a 63-percent increase over the sum available for fiscal year 1961. The major portion of the increase, $3.7 million, will permit significant advances in current program areas and substantially augmented activity in improving instruction at upper elementary and junior high school levels.
>
> You have a group of experts, college presidents and professors writing textbooks. Just what is the status of this?
>
> Dr. DEES. I can speak to that, sir.
>
> Mr. THOMAS. When will you wrap up the program?
>
> Dr. DEES. Your comment to the effect that this is one of our very important programs is quite correct. We feel this represents one of the breakthroughs in science instruction which has been made over the last 100 years, at least.
>
> Mr. THOMAS. How many new textbooks have been written by virtue of this program?
>
> Dr. DEES. At the secondary school level——
>
> Mr. THOMAS. To whom does the $10 million go?
>
> Dr. DEES. Primarily to groups of scientists set up in special study groups. For example, the Biological Sciences Curriculum Study, which operates under the aegis of the American Institute of Biological Sciences, the largest of the professional groups in the life science field, the School Mathematics Study Group——[73]

After insertion of some data from the budget, Dr. Dees continued his answer:

> Dr. DEES. SMSG was set up through the joint cooperation of the American Mathematical Society, the Mathematical Association of America, and the National Council of Teachers of Mathematics in the country. There are other groups in chemistry, and you will recall, I am sure, the work of the pioneer group, the Physical Science Study Committee, has resulted in the publication not only of a text but of a great many additional supplementary materials which aid the teachers, and which improve laboratory instruction. They actually have devised a large number of new laboratory devices and techniques, and they are also instrumental in the production of a large number of monographs which aid the students in their supplementary reading.
>
> Finally, with respect to the Physical Science Study Committee, their work on new and very much improved instructional films for use in classrooms is also important to mention.
>
> Mr. THOMAS. Do you pay any salaries in connection with this?
>
> Dr. DEES. The grant to the Physical Science Study Committee, for example, makes possible——
>
> Mr. THOMAS. That is a grant?
>
> Dr. DEES. Yes.
>
> Mr. THOMAS. How much?
>
> Dr. DEES. Up to the present time approximately $4.7 million to the Physical Science Study Committee.
>
> Mr. THOMAS. How is the committee made up?
>
> Dr. DEES. The leadership of PSSC has come from a group of scientists at MIT. Dr. Jerrold Zacharias there is the leading person.
>
> In addition they have drawn from the staffs of the University of Illinois, Cornell, Princeton, Bryn Mawr, and a large number of other institutions of higher education.
>
> In addition they have brought in a large number of high school teachers—outstanding high school teachers—to work with them during the summertime when they have done most of the writing that has been done in connection with this project.

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[73] U.S. Congress. House. A Subcommittee of the Committee on Appropriations. Hearings. Independent Offices Appropriations for 1962. Washington, U.S. Govt. Print. Off. 1961. p. 520.

At the present time the grants we make in connection with the Physical Science Study Committee are made to a group known as Educational Services, Inc., which is located in Boston, and which has as the chairman of its board Dr. James Killian, and has on the board a number of outstanding scientists and school administrators.

Mr. Thomas. You pay salaries, is it on a fee basis?

Dr. Dees. Salaries of the people who devote full time to this kind of activity are paid from the grant.[79]

Mr. Thomas pressed further to get some understanding of the expenses and expected duration of the curriculum projects:

Mr. Thomas. What is the ultimate goal—physics, math, chemistry?

Dr. Dees. Mathematics perhaps is the largest of the other activities. New books for use in the schools exist from grades 4 throuh 12 in mathematics, representing an entirely new approach to the teaching of mathematics at all of these grade levels.

Mr. Thomas. You already spent $21 million. When will you wind this up? When will the job be completed?

Dr. Waterman. For high school physics it is practically completed. We have listed only $200,000 for next year.

The others are not so far along. Engineers, by the way, are thinking of doing a similar thing.

Mr. Thomas. What is a good opinion as to the ultimate cost in the four big subjects—mathematics, physics, chemistry and biology?

Dr. Dees. They will run, in all likelihood in excess of $20 million.,

Mr. Thomas. You already spent $21 million.

Dr. Dees. Let me qualify my earlier comment to say that included, also, are the supplementary training aids which you mentioned in reading off the items on page 288. Furthermore the $21 million I spoke of last are distributed over all of the activities under the course content improvement heading.

For the secondary school programs proper we have expended through fiscal year 1961 to date approximately $11 million to $12 million for the secondary school component in this total activity.

In the natural course of events what probably will happen is that once the quantum jump, as we like to say, has been achieved in each of these areas, going from a completely unsatisfactory program of study to one which the scientific community and the teachers agree is a much better approach to the problem by field, that there then will be need to take a very long look at how one can coordinate physics and chemistry, mathematics-physics-chemistry, chemistry and biology, for example. It is our hope that this element of the problem which really could not have been done first——

Mr. Thomas. Let me interrupt. Your program envisages course content and textbooks. That is what we understand.

Dr. Dees. And all of the ancillary things that go with texts.

Mr. Thomas. High school and college—math, chemistry, physics and biology. When you get through with this program how long will it take and what is a good opinion as to how long it will last? You have already spent $21 million. Is it 50 percent completed?

Dr. Dees. At the college level——

Mr. Taomas. In high sheools it is almost wrapped up. What about colleges?

Dr. Dees. In the development of individual courses at the high school level it is at least half finished. At the college level we have merely begun to scratch the surface.

Mr. Thomas. How about chemistry in high schools and the other subjects?

Dr. Dees. Chemistry and mathematics are well along.

Mr. Thomas. You have already spent 5 years. Are you going te take another 5 years?

Dr. Dees. The first materials that will actually appear in hard cover as the physics book has and as its ancillary materials have will perhaps all be complete by fiscal year 1963.

This does not mean that this is the end of it because clearly these things need to be watched to be sure they are good and that they do mesh.

Dr. Waterman. We regard this as a research project. These materials have been tested in the schools so we think they will be accepted.

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[79] Ibid, p. 521, 522.

The hope is that this will carry its own weight in the future through this cooperation.

*   *   *   *   *   *   *

Mr. Jonas. How many people did you have in all working on this physics textbook? How many would you say?

Dr. Dees. There perhaps were in excess of 400 people at various times working on this, and that in addition to several hundred teachers who, as the workers in this field say, provided feedback information.

Dr. Waterman. They tried it out.

Mr. Jonas. Do you think that is the best way to get up a textbook? Would it not be better to pick out the best physicist in the country and let him write a textbook?

I never saw five lawyers who could write a brief. One man has to write it. You put 10 lawyers behind a table trying a lawsuit and you cause more confusion than anything else.

One man I am sure can do a better job than ten.

When you have 400 people you turn it into a debating society. Someone individual will have to do the writing.

Dr. Waterman. That was done. The 400 were required to determine what the course should include in such a way that this would be most acceptable to the majority.

Mr. Jonas. Each man had to be paid a salary or a lot of travel expense and other costs. You could have done this job in half the time with half the money in my humble judgment.[75]

C2. Inquiry into Publishing Arrangements

Members of the committee were very concerned about publishing arrangements, in spite of their approval of the quality of work evidenced in the physics text of the Physical Science Study Committee, which was beginning to be published and sold. The price of the text seemed high, considering that the development costs had been borne by the government. At $5.60 the book cost a bit more than most commercial texts in the field at that time. But to eliminate royalties, and to effect other economies that could be achieved by direct Federal printing and distribution, would have "underpriced" the existing market. The result, according to NSF, would have been a price so low as to provide a strong incentive for school boards to adopt PSSC texts. A rather complicated scheme had been devised by MIT and NSF to have MIT transfer the PSSC materials and copyrights to a new corporation, Educational Services, Inc. (ESI), which was independent of both institutions. It included among its board of directors:

James R. Killian, Jr., chairman; chairman, board of trustees, Massachusetts Institute of Technology.
Detlev W. Bronk, president, Rockefeller Institute; president, National Academy of Sciences.
Rev. Theodore M. Hesburgh, University of Notre Dame.
Frederick L. Hovde, president, Purdue University.
Joseph C. Morris, vice president, Tulane University.
Alfred C. Neal, president, Committee for Economic Development.
Carroll V. Newsom, president, Tulane University.
Gilbert Oakley, vice president, Educational Services, Inc.
Glenn T. Seaborg, chairman, Atomic Energy Commission.
Julius A. Stratton, president, Massachusetts Institute of Technology.
James E. Webb, administrator, National Aeronautics and Space Adminstration.

ESI in turn contracted with D.C. Heath and Company to print and distribute the physics text, in return for which ESI would receive royalties from Heath. These royalties would be controlled by NSF, and would be used to revise the text and perform other necessary functions related to improving the material. While PSSC material was to be available to other publishers for inclusion in their own texts, the Foundation pointed out that it could not be too free about this in order to protect D.C. Heath's economic interests. Mr. Hoff, general counsel of NSF, summarized some of these points as follows:

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[75] Ibid., p. 523-526.

> Mr. HOFF. Our general approach on this has been to make our grants apply to the preparation of materials, and from that point on let them carry their own weight. The choice of D.C. Heath was made after a great deal of canvassing of the industry to get a qualified publisher who would put it out at the lowest price commensurate with quality and with good distribution and everything else. The actual royalties coming back go to ESI in the case of physics, and there is a different arrangement for each of these things, but the use of the funds is controlled by the Foundation.
>
> The thought in back of many people's minds is that the feedback in terms of royalties will permit the constant keeping up to date of the book.
>
> Dr. WATERMAN. And the materials.
>
> Mr. HOFF. I don't know how much the cost could be brought down if there were no royalties but it is very minor compared to the question of whether it is to be priced at the market or under.
>
> If we were to actually subsidize the distribution and publication of the book, the price could be brought way down, but that has not been our idea. Doing anything like that would be almost to force the book into the school system.[76]

However, the questioning revealed that Members of the subcommittee were not entirely satisfied with their understanding of the arrangement at the close of the hearings. This is not to imply that the Foundation's arrangements were felt to be improper, but rather that the resulting structure was confusing.

C3. *New Programs for FY 1962*

The increase in funds for Fiscal Year 1962 again allowed the Foundation to fill some of the gaps that it felt were evident in the precollege programs. Some of the changes involved totally new programs, while others were the natural metamorphosis of older programs. Not all of these programs lasted very long, but one effort that grew sizable in Fiscal Year 1962 and did survive was the Cooperative College-School Science Program (CCSS). The 12th Annual Report described it as follows:

> The Cooperative College-School Science Program provides opportunities for higher educational institutions to present programs, as collaborative efforts with secondary schools, for the improvement of school science instruction. Projects typically group qualified secondary school students with teachers in intensive college-directed learning programs which may be course-oriented or provide research participation experience. The teacher participants serve as instructional aides, or in other suitable ways, thus gaining experience with advanced subject matter and with its impact on superior students. A desired result is that the teachers may develop improved science projects for capable students in their own schools.
>
> A total of 34 grants were made in this program in fiscal year 1962. Projects supported involve 2,100 participants, 13 percent of whom are secondary school teachers. Seventeen of the projects are summer offerings and the remainder academic year or combined summer and academic year projects.[77]

The exhaustiveness of NSF's programs in Fiscal Year 1962 is perhaps indicated by the following three programs:

SUPPLEMENTARY SCIENCE PROJECTS FOR STUDENTS

This program supports experimental projects, generally of a one-of-a-kind type. Four grants were made for the following purposes: to the National Academy of Sciences for the distribution of a career information booklet on mathematics;

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[76] Ibid. p. 529.

[77] 12th Annual Report of the National Science Foundation, Washington, U.S. Govt. Print. Off. [1963] p. 85.

to the National Science Teachers Association for the partial support of an American student delegation to the International Youth Science Fortnight in Great Britain; to Dartmouth College to support a program for the improvement of science education in the high schools of New Hampshire, to be conducted with the cooperation of St. Paul's School and the New Hampshire State Department of Education; and to the Council of Chief State School Officers for the preparation of a catalogue of instructional scientific equipment for secondary school use.

HOLIDAY SCIENCE LECTURES

Patterned after the famous Christmas Lectures of the Royal Institution of London, the Holiday Science Lecture project is an effort to bring distinguished scientists to students all over the Nation in a five-day lecture series during Christmas and Easter vacations. The project was originally supported under a grant to Rockefeller Institute of New York City, and is now administered by the American Association for the Advancement of Science. During the past year, Dr. Paul Weiss lectured in San Francisco and Dr. Rene Dubos in Cincinnati, repeating the series which they had developed under the Rockefeller Institute grant. During the 1963 calendar year there will be six to eight lectures in a variety of disciplines presented in selected cities across the country.

VISITING SCIENTISTS (SECONDARY SCHOOLS)

This special project enables professional societies in the basic disciplines—mathematics, chemistry, physics, and biology—to send distinguished scientists into secondary schools throughout the United States upon a school's request for such visitors. The visitors typically lecture on their scientific specialty, inform the students about opportunities in such fields of science, outline desirable educational programs for students wishing to enter scientific fields, confer with teachers and school administrators on new developments in curriculum and laboratory experiments, etc. The number of visits in any one State is small, for this is a national program which concentrates on those States where visiting scientists are not available under the State Academies of Science Program.[78]

The 12th Annual Report of the National Science Foundation also included a status report on curriculum improvement projects The following table from the Report depicted the situation as of the close of fiscal year 1962:

Subject	Year begun	Present status	Use 1961–62	
			Teachers	Students
Physics (PSSC)	1956	Commercial version available	1,800 to 2,000 partial use by 1,000.	80,000
Mathematics (SMSG)	1958	Definitive version available—Grades 7–12.	Unknown	409,000
Chemistry (CBAP)	1958	Revised version in trial schools; commercial version, September 1963.	200	10,000
Biology (BSCS)	1959	do	500	50,000
Chemistry (CHEM Study)	1960	do	124	[1] 12,000

[1] Ibid, p. 89.

Note: PSSC—Physical Sciences Study Committee; SMSG—School Mathematics Study Group; CBAP—Chemical Bond Approach Program; BSCS—Biological Sciences Curriculum Study; CHEMS—Chemistry Study.

C4. NSF's First Extensive Review by Congress

Certainly one important event of FY 1962 was the full review of NSF programs conducted by the House Committee on Science and Astronautics.[79] Though these hearings did not uncover any points of disagreement, they provided an exceptionally clear record of much of the philosophy, structure, and method of NSF education operations at that time. Dr. Bowen C. Dees, Assistant Director for Scientific Personnel and Education, made the presentation of the Foundation's education activities:

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[78] Ibid, p. 86.

[79] U.S. Congress. House. Committee on Science and Astronautics. National Science Foundation briefing. 87th Congress, 2d session, February 6 and 7, 1962. Washington, U.S. Govt. Print. Off. 1962. 139 p.

Dr. Dees. I shall today limit myself to saying a few things about the basic principles underlying these programs, simply reiterating some of the things that Dr. Waterman and Dr. Kelly and Dr. Bronk have already said, and then telling you about a very few of these activities in very broad outline.

In the first place, I would like again to call to your attention the fact that we are primarily concerned in these programs with this qualitative component that has already been discussed.

We base this principle on the fact already borne out by experience that if we can find ways of improving education, improving the quality of training, this will, in itself, motivate more students toward studying science and toward considering careers in science.

Second, we are concerned with the fact that in this area it is extremely important to involve in the deepest way possible the scientific leadership of the country so that people who are on the forefront of knowledge in the various fields will in fact take a role in developing new instructional materials, in providing instruction for high school and elementary teachers, as well as for their own students at the university and college level, and their own colleagues.

Third, we have the strong belief that, because of the vast complexity of the problems that we face in trying to see to it that at all levels and across the board in all fields, education in the sciences is to be improved, it is necessary to use a variety of approaches. No one approach can possibly be broad enough to take care of all of the needs that are seen in this domain.

With respect, then, to the programs, giving you just a sample of the things that we are doing, let me begin with the oldest of our programs, which is the program that we refer to as our fellowships activity. There are in fact a number of programs subsumed under this heading. They range in coverage from senior scientists who need additional experience in order to become still more proficient, through graduate students who are just on their way to becoming creative scholars down to and including teachers at the high school level.

We are concerned, therefore, in this program, with trying to see to it that individuals, highly selected, are chosen from those who apply solely on the basis of ability, and are then given the opportunity to improve their own competence through study in those places where they can best obtain the additional training that they need.

We stay in very close touch with the colleges and universities to see to it that these programs are kept flexible and to see to it that they in fact are responsive to the changing needs of education at these highest levels.

Turning to the largest of our activities, then, for a moment, let me say that the programs in education in the sciences, which now represent about a third of the Foundation's total activities, have been directed in very large measure, as Dr. Kelly has already pointed out, toward the supplementary training of secondary school teachers.

This has been done mainly through the program that we refer to as our "institutes program," although there are several kinds of institutes. Let me add, parenthetically, that the institutes apply not only to secondary school teachers but to college teachers and to a limited degree to elementary school teachers as well, but I shall at the moment refer only to one kind of institute program, and this is the one that we call the summer institute program for secondary school teachers.

We have, over the last several years—in fact, beginning in fiscal year 1954—been supporting fairly large numbers of these programs. The basic idea is to bring together a group of teachers, usually about 50, in a special setting on a university or college campus, and give them, on the average, 7 very intensive weeks of subject matter training in science.

These teachers, therefore, are able to return to their classrooms with an entirely new and refreshed outlook on physcis or chemistry or whatever it is they may have been studying, and we have abundant evidence that this technique, this mechanism, actually does improve the quality of teaching on the part of these teachers.

The Chairman. How many meetings do you hold a year, Doctor?

Dr. Dees. At the present time, for this coming summer, there will be approximately 480 of these programs, involving some 17,000 secondary school teachers of science and mathematics.

This is about the same level as we had last year in terms of the number of teachers reached, and represents roughly 10 percent of the high school teacher population in these fields.

Not only has our staff found, through visits to these programs, and through sending consultants to them, that they are doing an important job, but we also have had a number of research studies carried out by independent groups—I hold here, for example, one of a number of reports that we have had on this program. And I can say quite categorically that all of the evidence available to us indicates that this is indeed one of the most important and effective programs for improving science education that has thus far been invented.

As I have indicated, the program this coming summer will involve some 17,000 teachers. I would point out to you the fact that last summer, when we had about the same number of places for teachers in summer institutes, approximately 90,000 teachers applied for these places, and they submitted well in excess of 220,000 applications all together. This is a slight indication, at any rate, of the popularity of the program, and the belief on the part of the teachers that it is a worthwhile thing to do on their part and in terms of their improvement as teachers.

Turning, then, to still another area. A program which we are particularly concerned about at the present time, because it bears on this question of improving undergraduate college education, is a program that we refer to as "undergraduate research participation."

Through this mechanism we make it possible for universities and colleges to set up special training programs within their usual research context, to bring in able undergraduates and give them a taste of the work of the scientist. This is quite different from the usual course work. It enables the student to become a junior scientist during the time that he is in fact serving with his mentor in this way.

These programs in many cases are summer programs, but increasingly universities and colleges are finding it important to do this throughout the academic year.

Other efforts related to this one have also been mounted in an effort to be sure that we are in fact seeing to it that the undergraduate college level gets its due share of attention.

In particular, as we have looked at this problem of college undergraduate education, it has become abundantly apparent that one of the difficulties facing the colleges and universities at this level is the question of obtaining new, modern, or additional instructional equipment. This means, of course, the various kinds of apparatus that are required in the laboratories, and the special devices that are useful in presenting demonstration lectures and the like.

As a result we have introduced just this year a new program which will enable the degree-granting colleges of the United States to obtain from the Foundation on a matching fund basis, grants to help them push forward in the bettering of their instructional equipment in all fields of science.

It is our hope that this program, which at the present time we estimate can meet only about 2 percent of the known needs, can be expanded fairly rapidly in the future. The workload of proposals received has already indicated to us this year, although no grants have been made, that our earlier estimates with respect to the needs here were, if anything, conservative.

The last of the areas that I would mention, Mr. Chairman, is the area that we refer to in our shop as the "course content improvement area."

Under this heading we include a variety of activities, under which the various senior scientists of the United States are brought, in many cases for the first time, face to face with the problem of trying to improve instructional materials at all levels of study, including elementary, junior high, and high school, as well as college.

As Dr. Kelly has already pointed out, one of the things that we learned some time ago was that many of the instructional materials available in our schools were out of date, they were no longer reflective of the spirit, the tone, and not even of the latest findings in science in many cases.

This program has already been underway now for several years, and we are beginning to get some products which are being avidly sought by many of the schools of the country.

We find that not only are the scientists sure that these materials are better, but the school boards, the superintendents, and especially the teachers, are enthusiastic about these new materials.

One of the things that follows as an incidental, and not completely expected, effect is that we have learned from these experiences that students actually can learn more, they can learn more rigorously, and they can in many instances learn faster than had earlier been anticipated.

All together, in this past year, in its programs in education in the sciences, the Foundation made grants to some 570 colleges and universities throughout the United States. This indicates, since all of these grants were made on the basis of proposals individually reviewed for scientific merit that there is excellence, at least at some level and in some fields of science, in colleges and universities throughout this country.

One of the things we hope we can help with in this program is the building up of excellence in our universities and colleges, helping those that are already good to become better, helping those that have strong potential to improve their potential.

Thank you, Mr. Chairman.

[The following was submitted for the record:]

"NATIONAL SCIENCE FOUNDATION PROGRAMS IN EDUCATION IN THE SCIENCES"

"The National Science Foundation Act of 1950, as amended, authorizes and directs the Foundation, among other things, 'to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences, * * * to initiate and support programs to strengthen scientific research potential * * * and to award * * * scholarships and graduate fellowships in the mathematical physical, medical, biological, engineering, and other sciences.' The act also specifies that 'it shall be one of the objectives of the Foundation to strengthen * * * education in the sciences.' This report summarizes the Foundation's efforts to discharge these mandates and highlights progress during the last year.

"It is important to note that these efforts have been mounted with the fullest cooperation, participation, and advice of the scientific and educational communities. This active involvement of those communities is essential to assure that the programs and policies of the Foundation are fully consistent with the principle of a decentralized educational system subject to local control and the needs of individuals.

"A restatement of this principle is especially called for at this time in view of the findings of Nicholas DeWitt in his recent study of the Soviet educational system. This 850-page study ("Education and Professional Employment in the U.S.S.R.') was supported and published by the National Science Foundation as a part of its continuing examination of the problems of the supply, demand, and training of professional technical manpower. It clearly documents the fact that the Soviet educational system is producing more scientists and engineers than the American system, and at an increasing rate. But it also shows why. The Soviets feel that the primary purpose of their educational system is to train individuals to perform specific tasks for the state's purpose. It is not intended primarily to offer to its citizens educational opportunities to obtain the kinds of education and training they need to satisfy their own needs and aspirations. Nor is it concerned with breadth of education and training, either for the populace or the individual. This leads to the heavy current imbalance on the scientific side, particularly with respect to engineering. The education of the individual as a broadly educated, independent member of society has largely been replaced by training in a narrow function. While such a system is undeniably efficient in serving the current needs of the state it has a serious defect. Who can say where man's quest for knowledge will lead him tomorrow? Who can say what kinds of manpower resources will be required tomorrow?

"The Foundation shares and supports the traditional American belief that education can best serve the Nation if the needs of the individual are considered paramount. We believe that an educational system geared to the needs and aspirations of the individuals will produce both the broadly trained pool of manpower that assures the flexibility needed to meet new national needs as they arise and that individual excellence upon which progress depends. Although many scientists, engineers, and mathematicians are needed, numbers alone can never be an adequate substitute for quality and the more difficult the problem, the more important is the competence of the individuals working toward its solution.

"The problems of education in the sciences with which the Foundation is concerned are multiple and complex. We believe that there is no single grand solution to these problems. Rather, almost as many approaches are needed as there are separately identifiable problems. Operationally, the Foundation attempts to identify problems as precisely as possible, evaluate them in terms of their relative importance, and devise means of attacking them. The Foundation's approach to the improvement of scientific personnel and education has been since its inception based on specificity. The Foundation has felt, and continues to feel, that this is a wiser way to invest public funds than that of distributing funds on a more generalized basis.

"Traditionally, scientists—especially leading specialists—have not chosen to involve themselves in science education other than in their own classrooms and laboratories. They have not given sufficient recognition to the fact that education in science, like education in general, is a continuous process, each level building on the level before. The Foundation believes that the scientist's traditional disavowal of responsibility for education in the sciences beyond the confines of his own laboratory has become a significant aspect of the American education scene and a major impediment to improvement. For it is the working scientist, the man at the forefront of his field, who is best qualified to say with respect to his field of science what is most important and what is trivial, what is outmoded and what is contemporary, and thus what is most important for the teacher to teach and the student to learn. As a result of the lack of participation of scientists, science education at early levels had come to have too little solid content. Therefore the Foundation has considered its role in science education to be mainly that of obtaining the active participation and leadership of scientists in the processes of education in the sciences—the training of gifted students at all levels, the training of teachers in the sciences, the creation of better courses, and sharing their advanced and specialized knowledge and skills with their colleagues. As in its support of basic research itself, in science education the Foundation has chosen to support those activities which can best be dealt with by scientists of outstanding competence.

"The Foundation's science education activities are built around six basic program goals:

(1) The support of further training for high-ability graduate students and scientists (including among the latter those of established reputation);

(2) The support of the further education in the sciences of teachers of science at all levels;

(3) The support of special science education programs for talented high school students and undergraduate college majors in the sciences, programs that offer kinds and levels of education that cannot be provided under ordinary circumstances;

(4) The improvement of the content of courses in the sciences at all educational levels and the development of new scientific aids needed to teach the new courses;

(5) Partial support to colleges for the purchase of instructional equipment needed to improve the quality of science instruction; and

(6) Improvement of scientific literacy of the American public.

"The Foundation's earliest science education activity was that of identifying high-ability graduate students and advanced scholars and affording them opportunities to continue their scientific training. This is done primarily through the mechanism of fellowships, the applicants being evaluated solely on the basis of ability by panels of ranking scientists appointed for that purpose by reputable nongovernmental organizations. Fellows enjoy the opportunity to select the institution in which they will continue their study but must obtain admission thereto as individuals. The Foundation administers seven fellowship programs for five categories of advanced scholars: graduate students, younger scientists holding the doctorate degree, senior research scientists, college and university science faculty members, and especially well qualified high school teachers.

"Since the inception of the fellowship activity in the fall of 1951 through the 1961 operational year, a total of 64,000 applications have been received and approximately 17,000 awards made. The number of applications increases each year and the number of awards has increased to a reasonably corresponding degree. It should be noted, however, that the Foundation wishes to reserve this type of support only for the truly talented and therefore sets more or less arbitrary limits on the percentage of the target population which would be so supported.

"Attached hereto as Appendix I is a summarization of applications received and awards granted (or to be granted in the case of the current year) in each year for each separate fellowship program.

"Last year 276 different institutions were selected by the fellows as the places where they would study, 188 of them American colleges and universities and 88 foreign institutions. It is worthy of note that the constant increase in number of applicants has not resulted in a decrease in quality of applicant which has been and continues to be strikingly high. A singular development in recent years is the great increase in both numbers and percentage of awards going to the field of engineering, in spite of the fact that the Foundation does not allocate a specified number of awards to each field but instead is concerned with the ability of the applicant irrespective of his field. Graduate study has not been a tradition in engineering but this seems now to be changing. There is beginning to emerge a still-too-small group of persons who might be called engineering scientists as contrasted with those who engage in routine engineering practice. This small group will unquestionably in the near future bring about a wholly new kind of engineering much better able to meet the truly difficult challenges of the present period of rapid technological change.

"The principal mechanism chosen by the Foundation to improve the competence of teachers is the institute. As supported by the Foundation, an institute is an intensive course of study in science, engineering, or mathematics which is planned and taught by scientists on the staff of the college or university which conducts the institute. The content and manner of presentation, while modern science in content, are designed to meet the needs of teachers who are chosen for participation by the local staff. There is a wide range of types of institutes as to length of program, field(s) of study, and level of presentation; the Foundation continues to encourage variety so as to meet the needs of different kinds of teachers teaching in different circumstances and with varying degrees of competence in science.

"A summer institute is a full-time program of summer study in the sciences which is specifically designed for a group of teachers which would typically number 50 and last from 6 to 8 weeks. An academic year institute, as the name implies, would provide full-time study for groups of 35 teachers for an entire academic year. An inservice institute program provides part-time study opportunities for teachers during the regular school year. These groups, typically 40 to 45 in number, meet after their regular workday is completed or on Saturdays.

"From its inception in 1958 through 1961 the institute activity has experienced the following growth:

Year	Institutes supported	Number of participating teachers
1953	2	42
1954	4	97
1955	11	299
1956	29	1,390
1957	133	6,517
1958	230	10,432
1959	607	30,523
1960	648	31,074
1961	771	35,223
Total	2,435	115,597

"The current year programs are not yet completed, but it is estimated that a total of 918 institutes will be supported offering a total of 41,000 study opportunities. The principal emphasis of these institutes has been at the high school level; since the beginning of the program, slightly more than 89 percent of the participants have been high school teachers, slightly more than 7 percent college teachers, and 3 percent elementary school personnel. In the last year, Foundation-supported institutes were conducted in 350 colleges and universities in every State as compared with 331 in the preceding year. Each successive year more institutions have participated in the program and each year a larger percentage of small institutions have been involved, not because of Foundation policy as such, but because more such institutions are submitting for support proposed programs of high quality.

"In the 1961 programs, institute study opportunities were provided for approximately 17 percent of the high school teachers of scientific subjects, 3.3 percent of the college science, mathematics, and engineering faculties, 0.2 percent of the elementary school teachers, and 0.2 percent of the technical institute faculties; in each instance, there was no material change over the level of the preceding year.

"Approximately half of the funds available to the Foundation for the improvement of education in the sciences last year were devoted to this activity. This distribution of funds is the result of a carefully considered judgment that the institute program represents an exceedingly important component of American education. The academic community—teachers, school officials, and scientists—now consider subject-matter institutes as a necessary and continuing part of academic life and plan accordingly. Institutes have been instrumental in establishing new standards in teacher competence and teacher training and have been a powerful force in bringing about a shift in educational emphasis from a relatively pedestrian, often outdated context to rigorous study of rigorous subject matter. So successful has been the "Institute movement" that institute programs in fields other than the sciences are being developed by other Federal agencies. The institute programs are rapidly becoming grassroots activities in the best sense of the term. They are exerting their effect in all corners of the American educational scene and there are few schools that have not felt their influence directly or indirectly.

"The Foundation also administers other smaller programs whose purpose is the improvement of the technical knowledge and understanding of teachers. Most notable among these activities are those which enable unusually able high school teachers to participate in actual scientific research projects under the direction of scientists. At another level, college teachers who are not established researchers are afforded comparable opportunities. In 1961, grants in these programs provided experience in research to 469 high school teachers and 408 college teachers, in each case a slight increase over the previous year. A more important change, however, is the increase in the number of projects in which especially the participating college teachers are to continue their research during the school year with only nominal guidance of the 'summer research professors.'

"Somewhat comparable programs are supported for especially able high school and undergraduate college science, mathematics, and engineering students. In some projects the students do research as in the teacher research participation projects; in others, the instructional program more nearly resembles that of an institute; in still others, the students pursue individual studies under the guidance of scientists. Most are intensive full-time summer programs; others are extra-hours programs in the school year. The common feature of all is the fact that the students are given an opportunity to work and study directly with scientists in ways rarely if ever possible in usual classroom setting.

"The high school student programs provided this kind of educational experience for about 4,500 students in 1960 and about 6,400 in 1961. Comparable figures for the undergraduate college student programs are 3,400 and 4,650, respectively.

"The acceptance of these two program activities by the scientific and educational communities has been gratifying. They represent a fairly novel venture in modern educational planning and it seems likely that they possess those features of broad applicability to many types of situations which have made the teacher institutes such a conspicuous element of the present American educational scene. The current year's programs bear ample evidence of this interest. On the basis of previous year's experience, for example, the Foundation planned this year to make approximately 180 grants in support of undergraduate student programs. However, many more excellent proposals were received than had been anticipated, and so far support has been given to 399 of them; other grants will be made later in the year from among the several hundred additional proposals which have been received but not yet thoroughly studied.

"All too frequently, however, the implementation of newly developed undergraduate courses and programs of independent study and research has been delayed due to inadequate funds with which to purchase new and modern science instructional equipment. Because of this great lack, large numbers of beginning college students are now forced to use obsolete equipment which is sometimes inferior to that found in many secondary school laboratories. This situation is particularly critical in the smaller colleges long beset by financial problems. Therefore, this year the Foundation has launched a new program which will afford funds to universities and colleges for the purchase of science equipment for instructional purposes. Because the amount available for this activity represents only about 2 percent of the estimated need this year, it has been necessary to limit eligibility to degree-granting institutions and in addition limit both the number of requests each school may submit and the amount of any one grant. The program is now midway in its first year and no grants have yet been made; many good proposals have been received. The Foundation is giving the most careful consideration to the future of this activity and believes that it should be markedly expanded for the next few years. It should also be noted that this program does not provide a species of general support for instructional equipment. Rather, it is addressed to specific situations in which the full implementation of carefully conceived course improvements is being prevented for want of appropriate (of adequate quantities of) instructional equipment.

"Of signal importance among the Foundation's programs in support of education in the sciences are those directed toward the improvement of courses of study and the various instructional aids needed to teach such courses effectively. As in the area of science teacher training, our professional scientists have not for many years personally participated in the preparation of courses of study and textual materials other than for their own students. Hence, existing courses tend to bear too little relevance to science as it stands today and as it is understood by scientists. Therefore, the Foundation has sought to encourage leading scientists to become involved in devising new courses of study so that they are in fact based on contemporary science. Typically, a course content project consists of a group of leading research scientists who determine course content and groups of experienced teachers and psychologists who help in preparing the materials for classroom trial. The testing of the new course materials results in successive revisions until there eventually ensues a product which is judged to be worthy of adoption by those school systems that wish to use them. The course having been prepared and made available to those who wish to use it, in whole or in part, the Foundation then refrains from the support of activities which could reasonably be construed as constituting either an endorsement of the course by the Federal Government or an attempt by the Government to persuade school systems to adopt the course. The Foundation's position is simply that the new materials have been prepared by leading scientists and made available for use through regular channels: they should be adopted or rejected by schools on their own merits in competition with other available materials.

"There have been three important consequences of the Foundation's activities in the area of course content improvement. First, the idea that leading scholars have important contributions to make to course development is spreading rapidly and has given rise to the creation of a number of course development groups other than those supported by the Foundation—and in fields beyond the Foundation's scope. Second, the new course developments have been very popular with school systems and their adoption poses difficulties with respect to the qualifications of the teachers assigned to teach them, especially because the new courses are typically nontraditional in approach as well as in content. Thus there is a growing interplay between the Foundation's activities in science teacher education and its activities in support of course content improvement. Third, and perhaps in the long view most significant of all, is the fact that students at all age levels have been found to be capable of understanding (and enjoying to a degree wholly unexpected) subject matter of a high degree of sophistication, provided that the material is presented in the right manner.

"In the area of course content improvement in mathematics for secondary schools, textual materials developed under Foundation grants were made available during 1961 to anyone wishing to use them for grades 7 to 12; some 300,000 pupils are studying from them at present, and the most recently published books from commercial publishers show a strong influence of these new approaches. Work continues on alternative courses, supplementary materials for brighter students, programed presentations, and a long-term study of effects on students. The Physical Science Study Committee's physics course, a Foundation-supported project, is being used by more than 75,000 students, and part of the course by about as many more. That committee continues work on advanced topics, additional films, new monographs, and additional test batteries. The Biological Science Curriculum Study, the Chemical Bond Approach Project, and the Chemical Education Materials Study—activities comparable to that of the physicis group—developed second experimental versions of their courses, which are now being tried in schools. The biology and chemistry projects will make their materials available for general use by the fall of 1963.

"For elementary and junior high schools, the School Mathematics Study Group is in the second year of experimentation on content for grades 1 to 6; materials for 4 to 6 will be published for general use by the fall of 1962. Imaginative alternative approaches are being developed by groups at Stanford, Minnesota, Illinois, Syracuse, and Webster College.

"Under a grant from the National Science Foundation, the American Association for the Advancement of Science last year set up a series of conferences which involved some 200 leading scientists and educators in a searching study of the problems relating to the teaching of science in elementary and junior high schools. The study concluded that properly organized and presented science should form part of the curriculum for all grades from kindergarten through 9, a massive effort to develop sound and effective content is urgent and feasible, a variety of approaches and materials must be created, and a parallel drive to improve science education of teachers is essential. On the basis of a recommendation of the study, the association is organizing a planning and coordinating group to stimulate and foster the needed effort. Meanwhile, teams in the Northeastern States, Illinois, and California are already at work on course materials.

"For college, planning and coordinative groups of leading scientists have been set up in mathematics, physics, and geology; similar groups in engineering, chemistry, and biology will probably be operating by mid-1962. The range of existing course development projects is already considerable; work is proceeding on a series of films for fluid mechanics, new approaches to the teaching of introductory biology, analytical chemistry and introductory physics, as well as new guidelines for psychology courses and a sourcebook in anthropology. All of these projects, and others, have produced preliminary books, films apparatus, or reports during the year.

"With few exceptions, the adult public learns little about science other than that which is concerned with the more spectacular results of applied research and technology. Progress in science, however, depends and will increasingly depend upon public understanding of the role and requirements of science and technology in our industrial society. Although the Foundation has found several ways in which it can assist in improving the public understanding of science, this program area is still in a developmental phase and the dollar level for this year is the same as last. Methods designed to aid in the development of broad public understandings are (1) conferences during which editors and radio-television executives are brought together with scientists of note so that they may become better acquainted with science, (2) television presentations (films) and traveling exhibits designed to familiarize the adult public with the more fundamental aspects of science, and (3) the preparation of science study materials appropriate to adult education classes held under the auspices of colleges and universities.

"In 1961, in the area of education in the sciences, the Foundation received 3,108 proposals for the support of specific projects, exclusive of fellowships. These were received from 784 institutions in a total of some 40 programmatic activities, only a representative sample of which have been discussed above. Some 1,693 grants were made to 570 colleges, universities, and scientific organizations. Of the funds granted in these programs, 29.4 percent went to large institutions which characteristically award 100 or more doctoral degrees in a year; 19.4 percent, to those granting 30 to 90 doctoral degrees; 12.3 percent to those granting less than 30 doctoral degrees; 24.5 percent to those granting masters degrees in science but not doctorates; and 13 percent to those granting a baccalaureate-level degree only. The degree to which institutions of different types participated in specific programs varied according to the nature of the program. In the high school student programs more than one-fourth went to schools granting only the baccalaureate, greater than to any other type of institution. By contrast, in science education projects at highly advanced levels, major universities accounted for about 55 percent of the funds; colleges granting only baccalaureate degrees, only 0.4 percent.

"This pattern is not appreciably different from that of the preceding year when 2,651 proposals received from 763 institutions and 1,640 grants were made to 573 institutions. Viewed over a longer span of time, however, it is clear that each year more institutions are involved and the smaller ones are participating relatively more. Each year every State in the Union is represented. Some of the institutions receiving grants in these programs are among the world's most famous universities; some are little known beyond their own region. Some are very large; some, very small. The essential point is that each grant was individually evaluated and awarded on the basis of the excellence of the proposed project. Elements of institutional prestige or geographic location played no substantive role. There is inherent in these facts a most important lesson: excellence or the potential for excellence is widespread over the Nation. Given an opportunity, encouragement and judicious assistance many an 'underdeveloped' college, 'underdeveloped' teacher, 'underdeveloped' student can achieve standards of true excellence. The Foundation is deeply committed to identifying institutions and individuals that have the potential of excellent performance in the sciences and assisting them to realize their fullest capabilities." [80]

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[80] Ibid, p. 67-77.

APPENDIX I

STATISTICAL SUMMARY—FELLOWSHIPS

Fiscal year	Academic year	Graduate		Cooperative graduate		Graduate teaching assistants		Postdoctoral (regular)		Postdoctoral (senior)	
		Number of applications	Number of fellows	Number of applications	Number of fellows	Number of applications	Number of fellows	Number of applications	Number of fellows	Number of applications	Number of fellows
1952	1952-53	2, 685	537					283	38		
1953	1953-54	2, 930	498					368	24		
1954	1954-55	2, 865	631					461	59		
1955	1955-56	2, 931	657					458	53		
1956	1956-57	2, 892	715					508	87	159	35
1957	1957-58	3, 028	773					482	85	304	48
1958	1958-59	3, 804	925					513	118	259	67
1959	1959-60	4, 506	1, 022	2, 872	943	1, 260	563	778	158	241	73
1960	1960-61	4, 696	1, 076	3, 091	1, 043	1, 362	555	782	148	259	67
1961	1961-62	4, 875	1, 394	3, 241	979	1, 366	595	656	185	275	82
1962[1]	1962-63	5, 100	1, 549	3, 500	1, 200	2, 000	813	800	185	300	82
Total		40, 312	9, 777	12, 704	4, 165	5, 988	2, 526	6, 089	1, 140	1, 797	454

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[1] Estimated.

Fiscal year	Academic year	Science faculty: Number of applications	Science faculty: Number of fellows	Secondary schoolteachers: Number of applications	Secondary schoolteachers: Number of fellows	Total: Number of applications	Total: Number of fellows
1952	1952-53					2,968	575
1953	1953-54					3,298	522
1954	1954-55					3,326	690
1955	1955-56					3,389	710
1956	1956-57					3,559	827
1957	1957-58	416	100			4,230	1,006
1958	1958-59	694	214			5,270	1,324
1959	1959-60	1,069	295	1,578	579	12,304	3,633
1960	1960-61	709	282	2,221	477	13,120	3,648
1961	1961-62	754	279	1,866	310	13,033	3,824
1962 [1]	1962-63	1,000	335	2,000	275	14,700	4,439
Total		4,642	1,505	7,665	1,641	79,197	21,208

[1] Estimated.

D. FISCAL YEAR 1963—COOPERATIVE COLLEGE—SCHOOL SCIENCE PROGRAM INITIATES CURRICULUM IMPLEMENTATION

Fiscal year 1963 marked another year of advance for the Division of Scientific Personnel and Education (SPE), though the requested budget of $111.5 million for the Division was pared to about $91 million by the Congress. Still, this was a strong increase over the $78.6 million appropriation of fiscal year 1962. The increase in funds was primarily to expand existing programs "across-the-board" rather than to start any major new efforts. The Foundation proposed one small new effort, however: the retraining of retired military officers to become pre-college science instructors. The program would be a part of the Academic Year Institutes Program, and would train 36 officers at a cost of $250 000 in Fiscal Year 1963. This attempt to retrain talented people with technical backgrounds indicated the tremendous perceived need for science teachers. The hearings before the House Committee on Appropriations contained an extensive discussion of the teacher retraining provided by the institutes, and revealed a strong level of congressional interest in the need for more teachers with adequate science training.

Several interesting factors characterize this era. One is the on-going program in research participation for high school teachers that had come about as an extension of the original program of research participation for college faculty. The idea was very similar to the college effort, in that the teachers participated in research programs at universities under special arrangement and with the supervision of an active research scientist. The program was intended to reach those few teachers of unusual ability and training who could benefit from such an experience, in the hope that this involvement in research would better equip them to work with unusually talented students

Another interesting factor of fiscal year 1963 was the continuing expansion into elementary-level education. Though the investment in institutes for elementary teachers was only about $1 million, its focus on key teachers and supervisors, who would in turn train other teachers, served to magnify the amount of money spent. In addition, course content improvement funds for elementary education almost doubled, going from about $1.7 million in fiscal year 1962 to about $2.9 million in fiscal year 1963.

By and large, the Foundation's education efforts were having a very constructive impact on science education at the pre-college level, and the 13th Annual Report reflected NSF's great pride of accomplishment:

> Over the period of its existence, the Division of Scientific Personnel and Education has evolved a number of programs under which support is granted to scientists for projects designed to effect favorable changes in the processes of education in the sciences. Some of these programs are intentionally still small and experimental; some have been terminated; some have become impressive in size. One of the things that has been learned is that although small-scale experimental programs are very important in assaying the potential of new programs, they do not themselves initiate massive change. Massive change is effected only by a relatively comprehensive approach. This is not to say, however, that a program must be large enough to involve directly every relevant individual or institution in order to create effects that are felt by virtually all individuals or institutions. Rather, given an adequate magnitude—and this magnitude is never precisely measurable—a chain reaction begins which greatly enlarges upon the stimulus.
>
> It is now abundantly clear that the educational programs of the Foundation, most notably the teacher institutes and course content improvement projects, have succeeded in changing the overall aspect of education in the United States. The change affects far more than just science—and it is far from complete.
>
> The change is simply a rebirth of the idea that rigor, scholarship, and intellectual content are important. It is becoming respectable to be a first-rate student or a well-informed teacher. Further, it has become respectable for the eminent scholars to concern themselves with educational matters at all levels. Because the National Science Foundation has a unique relationship with the scientific community, the Foundation's programs have given scientists the vehicle for constructive involvement with educational processes without the feeling of loss of integrity as scientists. Clearly, the Foundation is only one of the organizations influencing modifications in American educational philosophy and practice. But—through its actions rather than through pronouncements or exhortations—the Foundation has become quite possibly the most influential body in American education.[81]

There was one important change in the Cooperative College School Science Program, creating a format which was destined to become the central focus of the Program a few years hence. According to the 13th Annual Report:

> A new type of activity even more specifically directed at the improvement of secondary-school science education is now supported under this program. It involves close collaboration between a college or university and secondary school officials in the planning, adaptation, and introduction of the newly developed science curricula into one or more nearby school systems.[82]

This later became a means of conveying information about available curricula to pre-college school administrators, the first step in *curriculum implementation* and an activity that would later come to attract criticism of NSF by some Members of Congress and from certain sectors of the public. The concern would be whether NSF was influencing local school boards and administrators to adopt NSF developed curricula, some of which would prove to be controversial and all of which would have been presumed to compete in the commercial market with other material on an equal basis.

E. FISCAL YEAR 1964—A RENEWED FOCUS ON GRADUATE EDUCATION

The appropriation to the National Science Foundation's Division of Scientific Personnel and Education continued its strong advance in fiscal year 1964. The support of NSF and its education programs in the Congress was sustained by a constant flow of public discussion, reports from the Office of the President—both from the President's Science Advisory Committee and from the Office of Science and Technology, now headed by Jerome Wiesner, who enjoyed a particularly close relationship to President Kennedy—and the growing activities of the House Committee on Science and Astronautics, which had held a hearing on NSF activities in 1962. The National Science Foundation was clearly benefiting from public concern about the "space-race" with the USSR. The excitement of the Nation's progress toward putting a man in orbit and of reaching President Kennedy's goal of landing a man on the moon served to sustain interest in science. The President's Science Advisory Committee (PSAC) issued a number of statements and reports on science education, one being the so-called Gilliland Report [83] which focused on graduate eduation and the need for more Ph. D. engineers. This appeared just in time to support the fiscal year 1964 appropriation request.

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[81] 13th Annual Report of the National Science Foundation. Washington, U.S. Govt. Print. Off. [1964] p 86.

[82] Ibid, p. 101.

In addition, President Kennedy recommended in his budget message to the Congress that greater attention be paid to science and to the needs of science. Bolstered by the continuing threat of Soviet technological prowess, as evidenced in the "space-race", and by the detailed recommendations of the Gilliland Report, the President made a strong appeal for more support to education in the sciences. Congressman Miller, Chairman of the Committee on Science and Astronautics of the House of Representatives, reiterated the President's appeal on the floor of the House on June 10, 1963 and expanded the discussion with the inclusion of lengthy correspondence between himself and Dr. Wiesner. Mr. Miller called for a joint effort between the Congress and the Administration to improve the production of scientists and engineers, saying in his letter to Dr. Wiesner:

* * * * * * *

> In my judgment, it is becoming imperative that the executive and legislative branches of the government join hands in this matter with an eye toward making the Federal effort to bolster research and technological training as effective as possible. While I think that the Nation in general has been doing a commendable job, I doubt if it will suffice in the future. The close association this committee has with the national space program and our recognition of the vast demands which this program alone is making upon our scientific resources leads me to the conclusion that better and more coordinated planning for the development of highly trained scientific talent is an absolute must in the years ahead. And, obviously, the needs of the space program are but a segment of the whole requirement.

* * * * * * *

The entire discussion in the June 10, 1963 Congressional Record is included in Appendix B to indicate the high degree of concern at that point in time. According to the White House, the Nation would have to double its output of Ph.D.s in the mathematical, physical and engineering sciences by 1970, to a total of about 7,500 per year.

Although pre-college education was not a part of the discussion, it clearly benefited from this concern at the graduate level. But the major attention was elsewhere as the NSF budget request was made for fiscal year 1964. Since this budget request represented a turning point in many aspects of the Foundation, it is summarized here in tabular form to show the strong shift in interest toward the problem of training more Ph.D.'s in science.

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[83] "Meeting Manpower Needs in Science and Technology"—Rept. No. 1: "Graduate Training in Engineering, Mathematics and the Physical Sciences," Presidents Science Advisory Committee, the White House, Dec. 12, 1962.

	Actual, fiscal year 1962	Estimate, fiscal year 1963	Estimate, fiscal year 1964	Increase (+) or decrease (−) fiscal year 1964/1963
Basic research support:				
Basic research project grants	$84, 757, 363	$106, 500, 000	$144, 000, 000	+$37, 500, 000
International science activities, research	200, 962	600, 000	1, 000, 000	+400, 000
Subtotal	84, 958, 325	107, 100, 000	145, 000, 000	+37, 900, 000
Development and improvement of institutional science programs:				
Instructional base grants	3, 730, 635	8, 400, 000	18, 000, 000	+9, 600, 000
Instructional equipment for undergraduate education	5, 018, 860	8, 000, 000	30, 000, 000	+22, 000, 000
Science education and graduate research facilities	26, 089, 317	31, 000, 000	90, 000, 000	+59, 000, 000
Science development program	0	0	33, 000, 000	+33, 000, 000
Subtotal	34, 838, 811	47, 400, 000	171, 000, 000	+123, 600, 000
Specialized research facilities support	20, 673, 792	24, 250, 000	28, 500, 000	+4, 250, 000
National research centers	9, 723, 600	14, 300, 000	20, 600, 000	+6, 300, 000
National research programs	12, 282, 181	19, 300, 000	35, 500, 000	+16, 200, 000
Science information services	9, 201, 294	10, 787, 957	14, 500, 000	+3, 712, 043
Science education programs:				
Fellowships	16, 800, 000	21, 500, 000	36, 000, 000	+14, 500, 000
Institutes	40, 875, 972	41, 500, 000	50, 000, 000	+8, 500, 000
Research participation for teachers	2, 374, 450	2, 865, 000	4, 140, 000	+1, 275, 000
Science education for undergraduates	4, 372, 639	4, 625, 000	6, 020, 000	+1, 395, 000
Science education for secondary school students	3, 419, 051	3, 460, 000	4, 340, 000	+880, 000
Specialized advanced science education programs	1, 405, 779	2, 650, 000	3, 300, 000	+650, 000
Training grants for graduate education	0	0	25, 000, 000	+25, 000, 000
Course content improvement	8, 989, 756	12, 000, 000	25, 000, 000	+13, 000, 000
International science activities, education	342, 801	400, 000	700, 000	+300, 000
Subtotal	78, 580, 448	89, 000, 000	154, 500, 000	+65, 500, 000
Science resources planning	1, 488, 031	1, 950, 000	2, 400, 000	+450, 000
Program development and management	8, 977, 545	11, 986, 785	17, 000, 000	+5, 013, 215
Subtotal	260, 724, 027	326, 074, 742	589, 000, 000	+262, 925, 258
Allocations to other Government agencies	97, 426	22, 364	0	−22, 364
Total	260, 821, 453	[1] 326, 097, 106	[1] 589, 000, 000	+262, 902, 894

[1] Includes $3,640,000 unobligated of fiscal year 1962 appropriation.

The proposed total budget increase was enormous in size: $262.9 million more than estimated obligations of $326.1 million in Fiscal Year 1963. Almost half of the increase would go for "Institutional Programs" such as Instructional Equipment for Undergraduate Education; Science Education and Graduate Research Facilities; a matching-grant program to provide general funds to those institutions who were doing NSF-sponsored research; and an important new program called the "Science Development Program." This last program was designed to double the number of top-quality graduate schools in science by providing large support for planned improvements and expansions.

There was a large increase of $14.5 million requested for graduate fellowships, and $25 million for a new type of "fellowships" called "graduate traineeships." These traineeships were designed to increase the number of stipends for graduate study in science in a way that would encourage greater geographic and institutional distribution. Rather than giving a fellowship directly to a student to pay expenses to attend the school of his or her choice, the traineeships were given to university science departments to support deserving students in those departments. The intent was to provide a means of attracting good students to those departments which were of high quality but which could not compete with the "top ten universities" in attracting students who had won NSF Fellowships. Fellowship winners had tended to congregate in a few of the very best schools, thereby adding further strength to schools that were already excellent.

In spite of the strong support from the White House, the NSF request for fiscal year 1964 was pared sharply. This did not occur as the result of the arrival of a new Director for NSF, though Dr. Leland J. Haworth did replace Alan Waterman in the interval between the House and Senate appropriations hearings. Rather, the problem was that the Congress objected to the rapid escalation of the NSF budget. Congress did not seem to envision the Foundation as a dominant figure in university research and education. Though the appropriations hearings in the House did not give much indication of Congressional sentiment, the hearings before the subcommittee of the Senate Committee on Appropriations made the issue quite clear. At one point Dr. Philip Handler, a member of the National Science Board at that time, tried to indicate that the Government had a responsibility to support the research of those people it had trained in science, only to learn that Senator Ellender had a very different concern:

> Dr. HANDLER. There is another point, too, sir. If you will do as you have done, support the educational efforts of the Foundation, if they bear fruit, you will be asked to spend more money on research. If we train more and more competent young people to do research, you are then bound to provide them with the means of doing so. If you do not want them to do that you should not train them in the first place.
>
> Senator ELLENDER. You will find out as time goes on, Doctor, that a lot of these institutions will learn where they can get funds, and that is how this amount is going to keep on growing. It is the same as any other project. For instance, we recently authorized spending of $900 million in underdeveloped areas in our country to provide work. Well, now that has grown to $2 billion. They just found out where they can get the money, and they just come on and get it. As I pointed out a while ago here, you are asking this year just in one single year for $267 million more than you got last year, which is indicative of what I am talking about, that many of these universities and colleges are finding out where they can get this and they are going to find some way to get it. Of course, it may be on a matching basis, they might get it from some of their, as you say, former students, and all of that. But yet the Government is going to be called upon to produce more and more as time goes on, and I would not be a bit surprised to see this thing go up to $1 billion within the next few years.[84]

Senator Ellender's views seemed representative of Congressional opinion about the President's science education program in 1963. The final NSF appropriation was $353.2 million, an increase of about $27 million over fiscal year 1963. Though the Graduate Traineeships survived, the Foundation elected not to implement the Science Development Program in fiscal year 1964. That effort was staffed but not funded until a year later. It came to be a major NSF effort for the next several years.

Events of fiscal year 1964 made it clear that the Kennedy Administration had a rather definite vision of NSF's proper role. That role would be as the developer and promoter of graduate institutions in basic science and engineering, particularly those with sufficient strength to exhibit promise of entering the highest quality ranks. The emphasis in the Haworth years would be increasingly toward graduate research and graduate education. Though the Fellowships and Traineeships of the SPE Division would prosper, the institutes would slowly decline in funds. But in the meantime, Congressional appropriation legislation would regularly mandate a minimum amount for institutes for high school teachers of science and mathematics. And in addition, those many teachers and faculty involved in the summer institutes would begin to complain in the next five years to Congress about the growing lack of NSF interest in their work, and thereby become a small but vocal political force tending to sustain NSF institutes.[85]

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[84] U.S. Congress. Senate Subcommittee of the Committee on Appropriations. Independent Offices Appropriations, 1964. Hearings, 88th Congress, 1st Session on H.R. 8747. Washington, U.S. Govt. Print. Of. [1963]. p. 860.

The 14th Annual Report of NSF for Fiscal Year 1964 indicated these changing directions. The *Director's Statement* in that year included the following statement of philosophy, indicating that NSF would focus its attention in pre-college education on trying to train students who would one day become research scientists, rather than trying to provide better science education for the general public:

> In the area of science education, heavy emphasis was originally placed on graduate education—particularly on support of graduate fellowships for predoctoral study. However, early in the Foundation's history, the staff became aware of the need for additional activities at collegiate and even precollegiate levels. There were many problems uncovered at these levels, leading to initiation of a number of programs.
>
> Because of the very broad mandate contained in its authorizing legislation, the National Science Foundation has been able to play a unique role with respect to education in the sciences. The authority for such activities resides in the portion of the act which authorizes and directs the Foundation to "initiate and support * * * programs to strengthen scientific research potential in the mathematical, physical, medical, biological, engineering, and other sciences. * * *" Thus, while the Foundation properly supports science education programs at many levels, the goal is to strengthen the potentialities for national research capability.[86]

Though Dr. Haworth's interpretation was entirely reasonable on the basis of the wording of the National Science Foundation Act of 1950 (as amended to 1964), it was not in such good accord with the "working definitions and interpretations" being forged in the House and Senate appropriations hearings. However, it seemed to reflect the Administration's position and priorities.

The Graduate Traineeship Program was given a strong start in fiscal year 1964. Further along in his *Director's Statement*, Dr. Haworth reviewed the new programs being started. He first mentioned the start of the Science Development Program and then said:

> A related though separate matter has to do with the Foundation's initiation, also in fiscal year 1964, of a new Graduate Traineeship Program. This activity, limited during its first year to engineering, resulted in the award of grants to 109 institutions; each grant provided for a specified number of Graduate Trainee stipends, totaling 1,220 altogether, plus special allowances to help defray the institution's costs incurred in providing a year of training for each graduate student receiving an award. Akin in several respects to the Foundation's fellowship programs, the Graduate Traineeship program differs substantially in that it passes on to the grantee institution the responsibility for selecting the students to be supported as Trainees. Because of the intimate connections between graduate education and research, it is clear that departments that are moving rapidly toward educational and research excellence need to be in a position where they

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[85] See, for instance: U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science, Research, and Technology. The Science education programs of the National Science Foundation: a report of the National Science Foundation and selected background materials. 94th Congress, 1st session. Serial A. January 1975. Washington, U.S. Govt. Print Off., 1975. 163 p. Committee Print.

[86] 14th Annual Report of the National Science Foundation. Washington, U.S. Govt. Print. Off., [1965]. p. XX ff.

> can build up their population of graduate students by offering support to carefully selected individuals. Since the Graduate Traineeship program makes this possible in many cases, it can also—though to a limited degree—be considered a program devoted to developing science potential throughout the Nation. In fiscal year 1965 this new activity is scheduled to grow markedly and to be extended to the mathematical and physical sciences. Still later it will be extended to the biological and social sciences. As it increases in size and scope, we believe the program will become an important factor in assisting both well-established and newer departments throughout the Nation.[57]

The 14th Annual Report also gave some statistics on the impact of the Institutes Program, accompanied by the following table:

PERCENTAGE OF ELIGIBLE TEACHER POPULATION ATTENDING NSF INSTITUTES, 1964

Teaching level	Number of institutes	Teachers attending	Eligible teacher population	Percent attending
College:				
Academic year institutes	22	226	125, 000	3.0
Summer institutes	75	2, 471		
In-service institutes	4	78		
Conferences	35	1, 052		
Subtotal	136	3, 827		
Secondary school (grades 7 to 12):				
Academic year institutes	59	1, 707	220, 000	16. 0
Summer institutes	439	20, 411		
In-service institutes	282	13, 085		
Conferences	2	55		
Subtotal	782	35, 258		
Elementary school:				
Summer institutes	37	1, 236		
In-service institutes	70	2, 118		
Subtotal	107	3, 354	[1] 1, 100, 000	. 3
Total	[2] 1, 025	42, 439		

[1] Includes all elementary school teachers, since nearly all teachers on this level teach science and/or mathematics.
[2] Actual number is 1,002, since 23 institutes serve 2 academic levels.

The Report also addressed a matter of growing concern to the Congress: the methods that NSF used to educate school personnel about the curricula which it had developed:

> The Foundation does not support or encourage activities which could reasonably be construed as constituting an endorsement of courses, textual materials, and related instructural devices by the Federal Government or an attempt by the Government to persuade school systems to adopt such materials. Fundamental policy in American education places responsibility for the choice of curricula for elementary and secondary schools, colleges, and universities in the hands of teachers, school administrators, school boards, facilities, and other appropriate local authorities. Hence, the Foundation directs that funds granted for course content improvement projects shall not be used in any way to promote the adoption of the products of such projects by schools or colleges. Grants are to be used only for the development of new instructional programs and materials and for the dissemination of information about them. Textbooks, laboratory guides, films and other audiovisual aids, laboratory demonstration apparatus, supplementary readings and other materials produced by NSF-supported projects are made generally available through commercial channels, at prices competitive with similar materials from other sources. There is no financial advantage for schools in using the products of Foundation-supported endeavors. The Foundation's position is simply that the new course materials have been prepared by leading scientists and teachers and that their own merit should determine their adoption or rejection by schools, in competition with other available materials.[58]

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[57] Ibid, p. XXIV, XXV.
[58] Ibid, p. 77.

In spite of such pronouncements, however, there inevitably remained the problem of how to maintain programs to educate teachers about the new methods and curricula without such a construction being able to be made. As time went on, the subject would continue to be questioned. And whether NSF personnel were consciously promoting the curricula developed by the Foundation or not, it would become almost impossible to totally avoid some appearance of bias or self-interest in this regard. The following points seem worth remembering:

(1) In the areas where NSF has decided to develop curricula, there has usually been a good deal of sentiment among educators that a new curriculum was needed. In some cases existing curricula have been felt to be outmoded, in other cases the curricula were essentially nonexistent. In any case, a demand usually existed before NSF became involved. As soon as a new NSF-supported curriculum was complete, it was therefore likely to be proposed as an institute offering by one or more institute director(s).

(2) The purpose of the Institute Program is to instruct teachers in new fields for educational emphasis, in new methods of education, and in new ideas within those fields that are already being taught. Since these institutes are closely coupled to the research community (i.e. institutes use faculty who are either researchers or who are in close touch with researchers during the academic year), it is inevitable that teachers attending institutes will be exposed to ideas from the research community—and it is the research community that creates NSF curricula.

(3) In offering training to teachers, some sort of curriculum or format must be adopted. It is inevitable that institutes instructors will have some preference for those curricula which are in accord with the sort of instruction which they regard as best. Thus, it is inevitable that NSF-developed curricula, which have been developed by scientists and which have been tested widely to ensure attractiveness to both teachers and scientists, will be referenced widely in courses offered by NSF institutes.

In summary, it would be very difficult to avoid some degree of disposition toward NSF-developed curricula, if only because of the fact that (1) NSF is creating curricula in fields where the demand is high and competition is weak and (2) the instructors of teachers in the summer institutes are very likely to favor NSF-developed curricula as a matter of honest professional preference. Whether NSF has or has not been impartial in matters regarding adoption of its own curricula, the appearance of such favoritism would probably have been almost impossible to avoid. Such an avoidance would almost have required that NSF curricula be rejected by the research community itself, which would have been a strange paradox indeed. Thus NSF would appear to have been doomed by its own successes in curriculum development.

F. FISCAL YEAR 1965—NSF BEGINS THE SCIENCE DEVELOPMENT PROGRAM

The request for fiscal year 1965 was large: $487.7 million. This would seem once again to have exemplified the priorities of the Kennedy Administration, even though that Administration had ended tragically in November 1963.

Under the Kennedy Administration scenario the National Science Foundation was to become more dominant in Federal support of university research and to play a powerful role in doubling the output of Ph. D. scientists and engineers by 1970 as recommended by the Gilliland Report.[89] Manpower projections of the early 1960's had predicted great deficiencies in science Ph. D.'s. While it is perhaps easy to say now with accurate hindsight that those projections were highly inaccurate, it must be remembered that a good many national problems of that time seemed to demand intensive scientific study for their solution. The space-race was certainly one important example, but there were a great many others. The computer industry was just beginning to be used widely out-side of government, opening vast new opportunities in industrial and financial management as soon as good analysis techniques could be developed. The electronic revolution was beginning to have a broad impact, and companies of all sizes were starting to design and to produce types of equipment that were totally new. And in addition, military applications of modern engineering techniques were multiplying enormously. The great confidence inspired by President Kennedy gave rise to a considerable optimism about the future of the United States; and, in retrospect, it seems not unreasonable that very few people were asking harsh and critical questions about the presumed enormous need for people with advanced science and technical degrees and the need for vast amounts of basic research.

F1. Congressional Concern About the Growth of Science Budgets

As NSF approached the half-billion dollar level, Members of Congress began to question whether the Federal Government was assuming an inappropriately large role in higher education. In the appropriations hearings for fiscal year 1965 in the House, Congressman Ostertag commented:

> Mr. OSTERTAG. Dr. Bronk, I think it is fair to say that in recent years science has played an important role and has received the deserved recognition that it has in life and development. I think it is fair to say, too, that our stimulation and progress has been primarily sparked by the competitive aspect, particularly in the fields of space and military, and our national security. But one of the things that seems to be troublesome is the fact that, starting with science and research associated with it, by virtue of our system and by virtue of many factors that are involved, that the Government of the United States is inclined to preempt the field, and that we are moving in a direction which does not give proper spread to the whole field of science and research and its applications.[90]

A moment later he asked:

> Mr. OSTERTAG. Are your educational institutions becoming too dependent on Government grants and other support which are associated with this entire field? [91]

Other members of the Committee on Appropriations expressed concern over reports that eminent university researchers did not teach, and they were worried lest the Federal Government's research support serve to take the best professors out of the classroom.

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[89] Op. cit.

[90] U.S. Congress. House. Subcommittee of the Committee on Appropriations. Independent Offices Appropriations for 1965. Hearings, 88th Congress, 2d session. Washington, U.S. Govt. Print. Off. 1964. p. 673-

[91] Ibid, p. 674.

Congressman Boland and Congressman Jonas were concerned specifically with the size of the NSF budget. To them, the Foundation seemed to be growing rapidly with no apparent termination in sight. They seemed to be searching for some way to measure what progress had been made and how much was left to be done. In Mr. Boland's words:

> Mr. BOLAND. What are the needs for the future? Most of the great spurt in the money for the National Science Foundation came, as you remember, after 1957, when the Russians orbited the first sputnik. Then the budget for the National Science Foundation grew enormously, which was fine. We all agree it should.
>
> I think we all had a reappraisal of what our shortcomings were in this Nation. We found the greatest shortcoming was in the very field in which this great Foundation was interested.
>
> So the National Science Foundation made recommendations which were accepted almost carte blanche by those in the executive branch of Government and by those in the legislative branch of the Government—and properly so.
>
> They pointed to our great lack of engineers. They proved that one of our great needs was additional teachers in the sciences and one of the ways to assist was to not only bring new teachers into the field but also to shore up the knowledge of those who were in the sciences and mathematics fields.
>
> This was our program, and this was the program that you persuaded us ought to be followed, and I think that we followed pretty well. Perhaps we have now caught up in this area—or have we caught up? Will the impetus supplied by the Foundation, by the Congress, by the people of our country, to improve our competence in this field carry us further? Have we reached a plateau with respect to mathematics and science and should we now be starting in some other direction?
>
> We are now, I think, just starting to feel the full bloom and blossom of all the efforts which this great Foundation put into its thought 7 years ago. We are now beginning to reap the profits by having a greater number of engineers, improved facilities in universities, and better teachers at all levels. Have we come to the point now where engineers are coming out of our ears? Do we have too many? What is the future here? [62]

The answer, given by Dr. Bronk, was to the effect that more science instruction and more scientists would help solve a variety of problems, from those in pre-college education to those associated with poverty and society. Scientific knowledge seemed to him to provide the basis for conquering a great many social needs. But questions such as Mr. Boland's served to indicate that some Members of Congress were cognizant of the changing role of NSF and of its growing responsibilities *vis a vis* the academic community and that some Members wondered whether such large responsibilities were appropriate. Their attention was on graduate-level institutions, however, and their concerns apparently did not affect the pre-college education programs. On the other hand, restrictions on the overall NSF budget would necessitate that certain programs not be allowed to advance; and, pre-college education soon was affected.

In presenting the budget request to the House Committee on Appropriations, Dr. Haworth said:

> A total of $137 million is proposed for the science education programs activity. The programs included within this activity have as their objectives the promotion of higher individual attainment in science education and the attraction of able students to careers in science, mathematics, and engineering in sufficiently large numbers to satisfy the Nation's needs for substantially increased scientific capability. The programs reach all levels in the educational system and are directed to the production of better teachers, better students, better courses, and better scientists. The Foundation's science education programs have given scientists a vehicle for constructive involvement with general educational processes and have helped change the overall attitudes toward scientific education in the United States.

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[62] Ibid, p. 676, 67.

> The science education programs operate within the framework of policies which require (1) that the programs supplement rather than replace traditional forms of support; (2) that no measure of control is assumed over the processes of education; (3) that the fullest involvement, cooperation and advice of the scientific-educational community is obtained; and (4) that improvements are sought, rather than providing massive support of existing activities.[93]

In a sense, this was his reply to some of the Congressional questions mentioned above.

F2. A Question About the Institutes Budget

Mr. Thomas inquired about Congress' earmarking of funds for the training of teachers of high school mathematics and science:

> Mr. THOMAS. Turn to page 239 of the committee print. Heretofore you have provided that of the foregoing amounts, not less than $37,600,000 shall be available for tuition, grants, and allowances in connection with the program of supplementary training for secondary school science and mathematics teachers.
>
> For a while you were a little cool to that language. Have you changed your mind? Do you still need it? You have $45 million here for institutes; fellowships and training is $54 million. We have to break that down. Did you spend all of your $37,600,000 last year?
>
> Dr. DEES. Yes, sir.
>
> Mr. THOMAS. You spent it all?
>
> Dr. DEES. Yes, sir.
>
> Mr. THOMAS. This is Dr. Dees' field. What do you think about this language; is it good, bad, medium, or indifferent?
>
> Dr. DEES. I think that the money that we are spending within that limitation is being well spent. It is not too much. It is about the right order of magnitude.[94]

The level of $37,600,000 mentioned by Mr. Thomas in connection with the programs for high school teachers was almost a regular feature of the NSF appropriations in the 1960's.

The budget request for fiscal year 1965 for the SPE Division included an estimated $33.6 million increase, for a total of $137 million. Fellowships and traineeships alone were to receive an increase of $24 million, of which only about $100,000 would be for pre-college teachers. Of the $2 million increase requested for institutes, $1.25 was to be used for instruction of pre-college teachers. Of the $4.0 million increase requested for curriculum improvement, $2 million was to be for college and university studies. The emphasis was clearly toward graduate instruction, in concert with general changes in NSF direction mentioned in the discussion of fiscal year 1974.

F3. A Question About Curriculum Publication Arrangements

In the House, the Committee on Appropriations again inquired into the business arrangements relating to publication of materials produced by the Course Content Inprovement Program. The methods of letting contracts was first examined and then the subject of royalties was raised by Congressman Wyman:

> Mr. WYMAN. Now, my question to you is, do you require in advertisement for bids that you send out to the publishing companies that they adjust their bids so that sales of the text can go to pay us back?
>
> Dr. DEES. What is required is that the royalty from any sales be held by the grantee organization in an escrow account which is under the control of the Foundation, meaning that it can be returned to the Foundation if it is not required for further work by the study group.
>
> Mr. WYMAN. All right. In this program have you arrived, with respect to the publishing of texts, at a point in which you can evaluate the amount of these escrow funds? Have you got any real money in any of these escrow funds?

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[93] Ibid., p. 708.
[94] Ibid., p. 813.

Dr. Dees. Yes, sir.

Mr. Wyman. How much?

Dr. Dees. I don't have the latest figure, but the answer is yes. And these funds are in fact either being used for the continuation of other aspects of the study groups' work, or in one instance, we do expect in fact to get some funds returned to the Foundation in the relatively near future.

Mr. Wyman. Is there any language in the basic acts providing for the Foundation that requires any return of such escrow funds?

Dr. Dees. I think the answer would be "No."

Mr. Hoff. It is permissive. There is plenty of authority to require it, but it isn't mandatory to require it. In other words, we can make grants, loans, or other arrangements which encompass that.

Mr. Wyman. When you say that this escrow fund is available for further use by the study group, I understood the chairman just to ask you a little while ago how long you thought this was going to be a continuing proposition. Now, at some point shouldn't Congress write into its legislation dealing with this subject a requirement that at least 50 percent of the cost of the study group or some percentage of some other formula should be refunded through this process to the general funds of the Federal Government?

Dr. Dees. Well, I think that this is related to the question Mr. Thomas asked, because it involves the continued activities. And let me point out what I mean by continued activities, Mr. Wyman. If we take, for example, the work of the School Mathematics Study Group, which has been one of the large grantees in this program, what is being done here is that NSF is using funds today that either come from sales of publications or that we provide them to carry out a long-range evaluative study of these items.

One of the elements of this entire activity, quite clearly, is that what is involved is a massive experiment to try to learn how to do a better job of teaching. One of the things that one must, therefore, do is to conduct experiments that are designed to give you the kind of information about the success of the effort that we cannot get for free, that is to say, one must set up a fairly large-scale testing program, a fairly large-scale followup program to see how the materials are in fact working.

And, therefore, this group—the Chemicals Education Materials Study, that is one of the major chemistry projects, and other groups similarly are attempting through what may be called longitudinal studies to get additional help to improve instructional materials over a period of time.[95]

F4. Do NSF Curricula Contain Controversial Material?

Then the inquiry turned to another important question in curriculum development—the inclusion of controversial material:

Mr. Wyman. How many of the texts have been published?

Dr. Dees. The total number, if we take just the high school area now, is three specific texts in the one field of biology. There were three versions, so-called, developed at the same time by this study group. There is a text in physics that happened to be the first one that was published commercially. There are two in chemistry. There are a number in mathematics, because they go down obviously from the 12th on down to the lower grades. And I don't remember the exact number, but it is of the order of eight there. So we are talking even at the elementary and high school level now about more than a dozen. I would be happy to supply for the record an exact accounting, but I don't have it in my mind at the moment.

Mr. Wyman. Who determines whether a junior high school in Ventura, Calif., for example, is going to use that text? You can't order them to use it, can you?

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[95] Ibid, p. 860, 861.

Dr. **Dees.** First, the State of California will determine whether this is or is not to be on their list of acceptable books, and then the Ventura School Board would determine whether they wish to use it themselves.

Mr. **Wyman.** Are these studies and these advanced texts to keep our science current, are these being pretty generally eagerly acquired by these various local school units around the country?

Dr. **Dees.** They are. Just to take the case of the biology series that I mentioned a moment ago, it is estimated—and these estimates are reasonably good—that half of the new books bought for schools in this past fall semester were one or another of these three versions.

Mr. **Wyman.** Do any of these texts deal in any of the controversial sociological or philosophical studies on communism and the cold war, and so forth?

Dr. **Dees.** In that respect, no. But it depends on what you mean by the word "controversial."

Mr. **Wyman.** Concerning the origin and the destiny of the universe, religion, Federal-State relations, and so forth.

Dr. **Dees.** I think the answer to that question is "No."

Mr. **Wyman.** So there has been no problem so far as you know of that aspect of Federal aid to education that you sometimes find people complaining that the Federal Government in such a process actually supplies controversial texts for influencing a youngster?

Dr. **Dees.** Well, I can give you the one example that we know of out of hundreds of thousands of these texts now that have been used.

Mr. **Wyman.** If it is not a fair representation——

Dr. **Dees.** It is one small school in one area of the country. They returned 30 books out of hundreds of thousands—and this is the only case we know about—because the treatment of human reproduction was a little franker than the teacher thought the community would wish to tolerate.[96]

Thus, at that point in time, March 1964, the National Science Foundation appears to have been cognizant that a potential issue could arise from local objections to material included in the new texts. The failure to consider revisions of its *laissez-faire* policies in education even at the prompting of Congress, would produce serious problems in 1975, to the apparent surprise of NSF.

The appropriations hearings in the House included a description of major NSF-sponsored projects in curriculum development to that date. It is reproduced in Appendix C for reference.

F5. Curriculum Oriented Institutes

The fiscal year 1965 saw few major changes in the pre-college education area of NSF. However, it is worth noting that the Division of Scientific Personnel and Education was split into three separate divisions effective January 1, 1965: (1) Pre-College; (2) Undergraduate; (3) Graduate. This change would seem to have been predicated on a desire to give greater identity to the graduate education programs.

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[96] Ibid. p. 861.

It should also be noted that by fiscal year 1965, Foundation-developed curricula had come to be a regular feature of the summer institutes. The table below shows that growth of curriculum-focused summer institutes:

SUMMER INSTITUTES FOR SECONDARY SCHOOL TEACHERS DESIGNED SPECIFICALLY TO PROVIDE BACKGROUND FOR TEACHING ONE OF THE REVISED CURRICULAR PROGRAMS [1]

[Includes Joint Institutes for secondary school and college teachers but excludes institutes for supervisors; S = single-field institute. M = multiple-field institute]

Year	PSSC	UICSM	SMSG	CBA	Chems	BSCS	ESCP	Madison	Total
1958:									
S	5								5
M									
1959:									
S	10	1							11
M	3								3
1960:									
S	8	3	1	3					15
M	4			1					5
1961:									
S	8	1	3	5	2	2			21
M	4	1				1			6
1962:									
S	9	2	6	4	5	4			30
M	5	1		3	2	4			15
1963:									
S	7	4	8	4	4	18			45
M	7	1		4	3	9			24
1964:									
S	10	4	9	3	4	27			57
M	6		3	1	7	9			26
1965:									
S	10	5	7	5	4	13	1	1	46
M	8	1	3	1	9	12			34
Total:									
S	67	20	34	24	19	64	1	1	230
M	37	4	6	10	21	35			113
Grand total	104	24	40	34	40	99	1	1	343

[1] Krieghbaum & Rawson, loc. cit. p. 256.

Note: PSSC—Physical Science Study Committee (physics); UICSM—University of Illinois Committee on School Mathematics; SMSG—School Mathematics Study Group; CBA—Chemical Bond Approach; Chems—Chemical Education Material Study; BSCS—Biological Sciences Curriculum Study, ESCP—Earth Sciences Curriculum Project; Madison—The Madison project—to train elementary and secondary level mathematics teachers.

IV. Graduate Research and Institutional Support: The Effect on Pre-College Education

As the decade of the 1960's progressed, the basic research establishment in universities began to experience support problems. These were viewed with alarm and tended to direct the priorities of the National Science Foundation further away from pre-college education. Though the prevailing attitudes were not antithetical to the needs of pre-college instruction, there seemed to be such strong interest in graduate education and research at the Foundation that pre-college education seems to have been overlooked or given a much lower priority then before. Since these external factors exerted such a powerful influence on the Foundation's education programs, a brief review of events seems appropriate as background.

It would seem that the events culminating in fiscal year 1966 had their origins much earlier, partly in Congress and partly in the university-based basic research community. Research had become big business; and when added to the Nation's development effort it was truly immense. Thus R and D seemed to the Congress to be a large operation that was growing at an uncomfortable rate.

The Congress seemed to be worried that the appetite of science had become very large, and yet Congress seemed unsure of how science operated and what its basic needs were. On the other hand, the recommendations from the Administration were to expand the scientific and engineering community, thereby implying an increased demand for Federal support in the future. To the Congress, there seemed to be no measure of the effectiveness or of the adequacy of the science effort in the United States.

Science budgets had been expanded enormously since Sputnik, and it seemed that some point of leveling-off should be in the offing. For instance, Federal support of physics research had grown at an average compound rate of 29 percent annually from fiscal year 1959 through fiscal year 1963, and yet the testimony of leading scientists in Congressional hearings indicated that the financial need of the physics research community was still growing.[97]

The picture of this sort of rapid and unbounded growth in research budgets must have been disconcerting. Given such ambitious advice by the science community, the Congress increased its oversight activities in an apparent effort to be in a position to form more independent judgments about science and research.

Though a comprehensive discussion of this topic would be beyond the scope of this study, two Congressional investigations are worth mentioning because of their influence on NSF and on the Congress' knowledge of science research. Both began at about the same time, late in calendar year 1963, and both were conducted in the House of Representatives, although the Senate would also become active in matters that affected the Foundation fairly soon.

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[97] See: *Physics: Survey and Outlook*, National Academy of Sciences, National Research Council. Publication 1295. Washington, D.C. 1966.

First, the House Select Committee on Government Research was created by H. Res. 504 on September 11, 1963, to "make a complete, full, and thorough investigation of the numerous research programs being conducted by sundry departments and agencies of the Federal Government" and to give special attention to:

> 1. the overall total amount of annual expenditures on research programs;
> 2. what departments and agencies of the Government are conducting research and at what costs;
> 3. the amounts being expended by the various agencies and departments in grants and contracts for research to colleges, private industry, and every form of student scholarships;
> 4. what facilities, if any, exist for coordinating the various and sundry research programs, including grants to colleges and universities as well as scholarship grants.

The Select Committee was chaired by Mr. Carl Elliott of Alabama and, in its brief existence of only about 18 months, produced a landmark series of ten major studies which detailed the operation of the Federal research and development program and recommended improvements. Though the focus of this activity was not directed specifically at the National Science Foundation, it certainly affected every Federal agency involved in research and development because of the fact that it delineated the management factors relating to R and D. Heretofore, the Congress had seemed to feel that a consideration of questions of science management might necessarily require a consideration of science itself; but the ten reports of the Select Committee clearly separated the basic dynamics of R and D management from the mysteries of science. In subsequent years, Congress seemed to become more willing to exercise its independent authority in assessing science affairs.

A. AN EXHAUSTIVE REVIEW OF NSF BY THE HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS

While the Select Committee laid the broad groundwork for understanding and evaluating the management of scientific research, the newly formed Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics began a long series of somewhat more specific examinations into Federal science.

In June, July and August of 1965, under the chairmanship of Congressman Emilio Q. Daddario, the subcommittee held extensive hearings on the operation of the National Science Foundation. This was an exhaustive review of NSF, and its psychological impact was indeed large. The hearings culminated in a report entitled: "The National Science Foundation. Its Present and Future." [98] While the Report lauded the Foundation for its fine work and said that there was "a great deal right with them", it also contained some harsh criticism:

> But the fact is that the Foundation has not kept pace with the demands of society nor adequately oriented itself within the shifting machinery of government.

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[98] U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development. Report. The National Science Foundation, its present and future. Committee print. Washington, 1966. U.S. Govt. Print. Off.

> Fundamentally it may be said that the Foundation has functioned, and still does, in a manner that is largely passive. It has not itself put a sustained effort into developing substance, form, and direction of the programs it supports. Once granted its annual budget, NSF has to a large extent followed a practice of waiting for talented outsiders to suggest appropriate projects on which to spend it.
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> * * * * * * *
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> * * * the time is past due for the Foundation to assume a more positive, dynamic stance. And there are at least three good reasons for this, too.
>
> The first is that the problems of living in today's environment are reaching proportions which are truly monumental. It is conceded that they will not be solved without an equally monumental lift from science and technology. Foundation guidance in focusing upon allied areas of appropriate research and education could be a major factor in maintaining the stability of a civilization which is today seriously threatened by the surfeit and concentration of people and their problems.
>
> * * * * * * *
>
> Secondly, the Federal Government's interest in and support of R. & D. has become so broad and pervasive that the development of national policy concerning it has become correspondingly difficult.
>
> * * * NSF is the only Federal agency with an exclusive scientific mandate. It should make itself heard, and should be listened to, accordingly. While the Foundation's mission may be less tangible or focused than those of other government agencies, it is equally as real. If there is a disposition on the part of either the Executive or the Foundation to regard NSF viewpoints as less significant vis-a-vis the so-called "mission oriented" agencies, that disposition should be erased.
>
> Thirdly, it is now apparent that as the Nation's scientific resources, including manpower, become more and more in demand to meet the exigencies of modern living, the Federal departments and agencies will depend more heavily on the Foundation to pursue avenues of research which they themselves cannot provide or afford. At the same time, the Government will need better overall evaluation of the status of our science resources and of individual scientific disciplines and their potential. The Foundation is the logical Government component to provide such assistance. It should be ready and able to do so.[99]

There followed several pages of specific recommendations, the last group of which made the only mention of education or of factors which might affect the Foundation's interest in lower levels of education and matters relating thereto:

> 4. In addition, it is submitted that a number of other contemporary questions and issues involving NSF deserve further scrutiny. These are matters which have been, or are being, discussed around the conference tables of both government and the scientific community. Administrative or legislative action on them may be required in the not-too-distant future.
>
> These include:
>
> The appointment and tenure of the Director—should his present fixed 6-year term be traded for a contemporary post to be held at the pleasure of the President?
>
> The danger of limited viewpoint which may arise from too much in-breeding within the Government's science advisory bodies. This is a worrisome point provoked by the fact that a number of the same people often serve simultaneously on the National Science Board, the President's Science Advisory Committee, advisory committees of the National Academy of Sciences or other Federal advisory groups.
>
> The proper balance in the Foundation's support of education and teaching as opposed to its support of research. How should this balance be reached? What criteria should be employed? Should there be increased emphasis on teaching and, particularly, efforts to draw good people into that profession? What relationship should evolve between NSF and the Office of Education?
>
> The proper balance in the Foundation's support of engineering vis-a-vis the physical sciences. Similar questions arise here.
>
> The methods and emphasis of NSF support of new curricula for the teaching of science and technology. Are the Foundation's present activities gaged to assure strong, competent, and sufficiently varied inputs into the drafting of such curricula?[100]

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[99] Ibid, p. XII, XIII.

[100] Ibid, p. XV.

In the 16th Annual Report of the National Science Foundation, Dr. Haworth gave an extensive accounting of the committee's findings and recommendations, but omitted mention of this entire section of questions and issues. His focus of attention seemed to be on the graduate level of education and on research.

The Subcommittee on Science, Research, and Development made an important additional contribution to the question of science policy by formally requesting the National Academy of Sciences to examine two questions:

> (1) What level of Federal support is needed to maintain for the United States a position of leadership through basic research in the advancement of science and technology and their economic, cultural, and military applications? (2) What judgment can be reached on the balance of support now being given by the Federal Government to various fields of scientific endeavor, and on adjustments that should be considered, either within existing levels of overall support or under conditions of increased or decreased overall support?

The Academy assigned these matters to its Committee on Science and Public Policy, which produced a massive set of reports on the needs for basic research support.[101] The focus of these reports was primarily toward the problems caused by the recent reduction in the rate of growth of Federal support for research. Stated most briefly the problem seemed to be the result of the independent actions of the many agencies supporting basic science. With each agency responding to its own priorities the combined effect had slowed the rate of increase in Federal research money.

Though the Viet Nam War may have played some hidden role at that early time (1965) it seemed that the basic problem was the result of changing agency priorities in the absence of a national policy for science and in the absence of strong coordination for R. and D. The National Academy of Sciences report on physics, for example, recommended a minimum growth in research support of 16 percent per year through 1969 to maintain a healthy research climate. This was modest in terms of the 1959 to 1963 average of 20 to 29 percent (depending on what elements of NASA were included), but seemed more reasonable than the 6–7 percent increases in 1964 and 1965. But research support was apparently at the end of its era of tremendous growth.

As other agencies de-emphasized research, the Foundation faced increasing pressure to assume greater responsibility in supporting universities and graduate education. In subsequent years the reallocation of resources in other agencies to meet problems of the Viet Nam War would create further demands on the Foundation to assume even more of the research load.

Thus from the standpoint of the NSF administration in 1965, there undoubtedly seemed to be a growing need to put its resources in areas other than pre-college education, particularly basic research and graduate education in science. Top priority was apparently toward increasing the quality and quantity of graduate science education through traineeships, fellowships, and various institutional programs such as the Science Development Program.

The National Science Foundation could hardly be said to have been unsympathetic to pre-college science education—in fact, it produced an interesting description and justification of its activities in that area for the House Committee on Science and Astronautics in 1965[102]—but there seems to have been a diminishing interest in creative planning for the pre-college education area after the Gilliland Report made its impact, particularly after the research funding problem began to be discussed in calendar 1965.

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[101] Summary Report: "Basic Research and National Goals: A Report to the Committee on Science and Astronautics, House of Representatives." National Academy of Sciences. U.S. Govt. Print. Off., Washington, D.C., 1965.

B. FISCAL YEAR 1966—EDUCATION FUNDS SHIFT TOWARD GRADUATE SUPPORT

Fiscal year 1966 produced some difficulties for pre-college education programs at NSF. In the budget submission, Summer Fellowships for Secondary School Teachers ($826,000 in fiscal year 1965) had already been eliminated as unworkable and less productive of graduate degrees than the summer and academic-year institutes, which had produced 2,016 masters degrees in 1964.

In terms of obligations at the end of the year, the following could be noted: the support of pre-college education had been reduced by about $3.2 million while the entire obligations for all areas of education at NSF increased by about $3.9 million. The major increases within the budget were a $7.3 million increase for graduate traineeships and a $2.6 million increase in graduate fellowships.

It appears that a decision must have been made to shift funds to the graduate programs from the pre-college programs. This, of course, would not have been unreasonable from the viewpoint of the Foundation's administration or the National Science Board. Their responsibility, as they saw it, was to promote research and graduate education.

It was not until August, 1972 that the NSF legislation was amended to state that the Foundation is authorized and directed to ". . . initiate and support basic scientific research and programs to strengthen scientific research potential and science education programs *at all levels* . . ." (emphasis added).[103] Pre-college education was, and possibly still is, regarded by NSF as an important ingredient in the preparation of students for graduate study. But it apparently was not regarded as a separate and definite responsibility of the Foundation.

Viewed on that basis, it is quite reasonable that the National Science Board has never had a member who spoke primarily for science education at the pre-college level. Rather, pre-college matters have had to be articulated by interested Board members whose professional obligations were either to research or to education above the high school level. Under conditions of stress, such as the marked change in the rate of increase of Federal research support represented to the scientific community, there has been no member of the Board who would work primarily to inhibit a change in the Foundation's priorities away from pre-college education. The separate division status for Pre-College Education may thus have increased the vulnerability of these programs in fiscal year 1966.

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[102] U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research and Development. Science Education in the Schools of the United States. Report of the National Science Foundation. Washington. U.S. Govt. Print. Off., 1965 Committee Print.

[103] Public Law 81-507 as amended, including Public Law 92-372 which added the words "at all levels".

C. FISCAL YEAR 1967: THE EDUCATION BUDGET LEVELS OFF

Fiscal year 1967 was the first year since fiscal year 1961 when the obligations for education at the Foundation were essentially equal to obligations of the previous year. In the appropriations hearings in the House and Senate there was little mention of pre-college education. The focus was on graduate education: improving the quantity of Ph. D. production in science and improving academic excellence through institutional programs.

This was in accord with a strong policy statement made in September, 1965 by President Johnson in a directive entitled *Strengthening Academic Capability for Science Throughout the Country.* This directive stated that:

> To the fullest extent compatible with their primary interests in specific fields of science, their basic statutes, and their needs for research results in high quality, all Federal agencies should act so as to:
>
> a. Encourage the maintenance of outstanding quality in science and science education in those universities where it exists;
>
> b. Provide research funds to academic institutions under conditions affording them the opportunity to improve and extend their programs for research and science education and to develop the potentialities for high quality research of groups and individuals, including capable younger faculty members;
>
> c. Contribute to the improvement of potentially strong universities through measures such as:
>
> > Giving consideration, where research capability of comparable quality exists, to awarding grants and contracts to institutions not now heavily engaged in Federal research programs;
> >
> > Assisting such institutions or parts of institutions in strengthening themselves while performing research relevant to agency missions, by such means as establishing university-administered programs in specialized areas relevant to the missions of the agencies.

To the National Science Foundation, this was a very strong encouragement for its efforts in institutional development, in research, and in fellowships and traineeships. The Johnson Administration had apparently decided to act on the Gilliland Report on manpower and upon the National Academy of Sciences reports on Federal research support.

The appropriations hearings in the Senate were largely devoted to a competing issue: the failure of the Mohole Project, which was a geophysical experiment that had captured a good deal of attention.

In his prepared statement to the House Committee on Appropriations, Dr. Haworth made no mention of pre-college education, though he gave considerable attention to advanced education. This would seem to indicate a change in priorities.

On the other hand, Dr. Philip Handler, then vice chairman of the National Science Board, indicated in his prepared testimony that curriculum development and improvement was essential for the improvement of teaching at the pre-college level. Since he had participated in the Biological Sciences Curriculum Study, he undoubtedly was most interested in that particular subject area of the curriculum development effort. However, his written statement indicated a general regard for the importance of curriculum development:

> With respect to primary and secondary school education, it is painfully clear that there can never be a supply of gifted and trained teachers sufficient to the national need. It is imperative, therefore, that the Foundation develop all possible means for assuring optimal substantive and professional training of those who are to be the science teachers of the future. This entails development of specific curriculums and curriculum materials for this group and establishment of standards

for performance. A forceful thrust is essential to assure that training of teachers for tomorrow is conducted along modern lines in all aspects of science and that the education of the teacher includes a sufficient substantive base which, if need be, should be substituted for excessive courses in education. Once engaged in the teaching process in primary and secondary schools, these same teachers will require teaching materials of the best possible quality. The latter can only be prepared by active scientists alive to the currents of interest and excitement in their own fields. It must be a continuing responsibility of the Foundation to see to it that such materials are constantly in the process of upgrading at all educational levels and in all areas of science.

Teachers who are not themselves constantly engaged in the expansion of the body of knowledge which constitutes a scientific discipline, "research," all too rapidly lose touch with the continuing thrust of developments in that discipline. Accordingly, there is and will be a continuing need for the development of mechanisms for assuring the continuing education of such teachers. The current device—the Institute—undoubtedly represents only the opening wedge in this general area. Improved devices must be developed and the total level of activity grown to a sufficient magnitude to assure the intellectual vitality of as large a fraction of our teachers of science as possible.[104]

C1. An $860,000 Reduction for Pre-College Education

It would seem that the Johnson Administration must have been reexamining its priorities as the Fiscal Year 1967 budget request was being drafted. During the appropriations hearings in the House, Congressman Jonas asked why the total NSF request for Fiscal Year 1967 was $5 million less than it had been in fiscal year 1966. Dr. Haworth stated that the reduction had occurred in consequence of considerations of the total Federal budget, and later admitted that the Bureau of the Budget had done the paring.[105] Perhaps the problem was the increasing cost of Viet Nam operations.

The final appropriation for NSF was identical to that for fiscal year 1966: $479,999,000. Funds for basic research increased by $10 million to a level of $167.8 million, though the elimination of Mohole ($16 million in fiscal year 1966) and other internal adjustments produced a reduction in the total research budget (including national centers and national research programs) of about $15 million to a level of $220.9 million. The total for institutional programs increased by about $1.5 million to a level of $79.7 million. *And in contrast, the total support for science education was reduced by about $1.0 million to a level of about $123.4 million.*

Redistributions within the education budgets once again showed greater emphasis on the graduate area. Fellowships and Traineeships, which no longer included any pre-college effort, increased by about $1.4 million to a level of about $45.9 million. Support for institutes declined by about $2.6 million to a total of $37.9 million, with $3.1 million of the reduction being taken from pre-college programs (partly compensated by transfering elementary school teacher programs to the Cooperative College—School Program which increased by about $0.26 million). Special Projects for high school students declined by about $0.3 million to a total of about $0.6 million. Science Education for Secondary School Students stayed roughly constant. On the other hand, Course Content Improvement increased by about $2.8 million to a level of about $18.4 million. Roughly $1.8 million of that increase was for the pre-college area, the rest having been assigned to college and university studies.

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[104] U.S. Congress. House. Subcommittee of the Committee on Appropriations. Independent Office Appropriations for 1967. Hearings, 89th Congress, 2d session. Washington, U.S. Govt. Print. Off., 1966. p. 58.
[105] Ibid, p. 65 and 66.

The result was that pre-college education support decreased by about $860,000. In addition, funds had been shifted toward the Course Content Improvement Program from the Institutes Program and there were no longer any institutes for elementary school teachers. The 17th Annual Report of the National Science Foundation described the changes as follows:

> A number of Foundation education programs are being strengthened.
>
> The decision was made during the year to provide greater support for the Cooperative College-School Science Program as a means of adapting new materials, approaches, and techniques—developed to improve the quality of instructional programs—to the specific needs of school systems as determined by local educational authorities. This program permits the school system responsible for the implementation of new or improved curricula to obtain professional assistance and advice on curriculum change and teacher training from subject-matter experts at the college level. The Cooperative College-School Science Program serves as a complement to other Foundation programs designed to improve science instruction at the pre-college level.
>
> In an effort to stimulate highly innovative science education activities more dollars were channeled to the Foundation's program for Special Projects in Education at the pre-college level. This program provides assistance for proposed ideas which reveal new and imaginative approaches to problems in science education but which fall outside the bounds of other formally established programs. Some examples of the types of activities covered by this program include experiments making use of new educational technical resources such as computers, television equipment, video tapes, etc., and the mobilization of community resources (museums, for example) for the enrichment of school curricula.
>
> Additional funds were also provided during the year to strengthen the Course Content Improvement Programs, which enable scholars and competent teachers and educators to create new instructional materials for the teaching of science, and to strengthen programs for the supplemental training of college teachers.[106]

C2. Elementary Teacher Institutes Terminated

The matter was elaborated on again later in the text:

> As usual, this year the Foundation faced the problem of providing continued support for activities which have proved their effectiveness, while at the same time supporting innovative work which may develop even more effective approaches to the improvement of pre-college science education. To create the best possible overall program with the funds available, the Foundation terminated its support of institute programs for elementary school personnel and the program of Visiting Scientists for Secondary Schools. Concurrently, it increased its support of a wide variety of experimental projects in areas related to pre-college education. Also, through the Cooperative College-School Science Program, more emphasis was given to curricular reform and teacher training activities in the context of the needs of school systems. This program has considerable potential for developing elementary and secondary school science. Excellent new curricula for these levels are now available for selection and adoption by school systems, which will help close the present gap between innovation and utilization.[107]

C3. CCSS and Elementary-Level Curriculum Implementation

The Cooperative College-School Science (CCSS) Program represented an attempt to deal more effectively with the kinds of problems the schools seemed to be having. The 17th Annual Report gave a discussion of how CCSS had begun to operate, giving an insight into how elementary teacher training and curriculum implementation were combined under the Program. NSF officials regarded this program as an important mechanism for improving elementary education without having to provide direct training (through institutes) to the very large numbers of elementary school teachers who instruct in science:

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[106] 17th Annual Report of the National Science Foundation for the Fiscal Year Ended June 30, 1967. U.S. Govt. Print. Off., Washington, D.C. p. 12, 13—Note that budget figures reported in this study do not indicate an increase in funds for Special Projects to Education in the pre-college area.

[107] Ibid., p. 132.

Cooperation in School System Improvement

Effective implementation of advances in curricular reform usually requires the advice of experts in making selections from various alternative courses, assessing the implications of changeover to a new curriculum, and the availability of specialists to help train the teaching staff. These important elements are frequently unavailable to the school administration seeking to bring about immediate improvements on a large scale.

One solution to school system improvement problems is offered through the Foundation's Cooperative College-School Science Program. This program provides for collaboration between the staff of a school system and the science faculty of a college or university. Experts in the subject matter of science and mathematics are thus made available for consultation and to conduct the teacher training needed by the local schools.

An effort supported by the Foundation in fiscal year 1967 will serve to illustrate the kind of cooperation that makes for desired improvement. The Unified School District in Lawrence, Kans., requested assistance from the University of Kansas in planning and implementing a science program in its elementary schools. The university will conduct a project for the elementary teachers and supervisors which will focus on two activities. First, the teacher-participants will be given training, including laboratory work, during a summer phase so that they will have the necessary background material for working with one of the improved elementary science projects. The second phase consists of a coordinated academic-year program of weekly meetings, demonstration classes, and assistance with implementation of the elementary science materials. At the conclusion of the project, the school district will have adopted improved science curricula for the kindergarten through the eighth grade with trained teachers who understand how to use the materials.

Another interesting example of the cooperative effort is a project supported at the University of Colorado. The university operated two identical 5-week programs in cooperation with Boulder Valley School District and Jefferson County School District during the summer of 1967. The major goal of this project was to improve and strengthen the school offerings in mathematics and science by using the computer as an instructional tool. For the Jefferson County Schools this involved operating time-sharing computer consoles in the high schools so that the teachers and students could have direct access to the computer. The teachers and students from the Boulder Valley Schools traveled to the University Computer Center during the academic year to have access to a computer. Materials and techniques developed during the summer are scheduled for use in the 1967-68 academic year.

Implementation of new curricula requires of the elementary school teacher not only increased proficiency in subject matter but often also reorientation in philosophy and methodology. Under the Cooperative College-School Science Program, the work of the Madison Project with the school systems of Chicago, New York City, San Diego, Los Angeles, and Philadelphia is providing a model for the introduction of improved mathematics teaching at the elementary level. More than 600 teachers in each of the school systems underwent intensive instruction with project materials developed under the Course Content Improvement Program during the summer of 1966 and the following academic year.

From this broad base, key teachers were selected to receive further training so that they can become resource staff for the school system, able to lead their own in-service programs and function as master teachers, supervisors, and curriculum specialists. The experience gained in these continuing "big cities" mathematics education seminars has already been put to use in six workshops held in the summer of 1967 to train similar resource staff for the major elementary science and social science curriculum sequences now being developed under the Course Content Improvement Program.

The Cooperative College-School Science Program has had an extended period of growth, from a few grants for small experimental projects in fiscal year 1961 to a level of 52 grants totaling $2,296,295 in fiscal year 1967. Funds awarded this year represent an increase of 17 percent over the amount awarded in fiscal year 1966.[108]

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[108] Ibid., pp. 134, 135-137.

Though the priority questions in allocating funds within the Foundation did seem to be resolved in favor of graduate education and research, it would seem from the extensive discussions in the Annual Report that in 1967 the Division of Pre-College Education was attempting to be innovative and to fund proposals that seemed to provide creative responses to the actual problems of pre-college science instruction. Their funds were extremely limited, however, and the Foundation's reluctance to undertake long-term commitments or to initiate programs from within itself produced a multiplicity of small efforts whose total impact is often hard to appreciate. It would appear, however, that the staff in the Division of Pre-College Education were improving their cost effectiveness and were eliminating some of their programs whose impact was necessarily limited to a few individuals at a time. But greater cost effectiveness would lead NSF to work more closely with schools and school systems and to put increasing emphasis on curriculum implementation.

C4. Continuing Congressional Interest in Curriculum Development.

In the House appropriations hearings for Fiscal Year 1967, as in years before, the committee wanted assurance that the Foundation was conducting its curriculum development activities with care. The new subcommittee Chairman, Joe L. Evins of Tennessee, promoted a very careful discussion into the matter:

> On page 226 you make reference to the course content improvement program in all fields of endeavor, development of improved instructional materials from kindergarten through college. How is this accomplished and what are the mechanics and techniques?
>
> Mr. RIECKEN. A typical course content improvement program begins with one or two scientists who undertake to devote their attention to improving the nature of instructional materials available in their discipline and closely related disciplines. They generally organize through a university or occasionally through a professional society or nonprofit group and get the cooperation and collaboration of a number of their colleagues.
>
> Our stress here has been on involving first-rate scientists in these projects but not overlooking or ignoring the contribution that classroom teachers and professional educators can make to the method of presentation.
>
> Most generally there is a central core group, a small administrative group that keeps the project running. The heavy work is generally done during the summertime when the scientists are free from their teaching obligations at their own universities. They come together in writing groups to prepare and try out materials with the cooperation of educators and classroom teachers. When they have perfected a first-run trial version, they usually enlist the assistance of several schools or school systems to make further trials of the materials under actual classroom conditions with ordinary teachers using the materials.
>
> Following this first runthrough, the materials are further revised and readied for publication.
>
> Mr. EVINS. This is improving the course content of textbooks from kindergarten to college. Now, let us say California would like it one way and the South another way and New England would like it another way. How do you accommodate all of these requests in the State educational system?
>
> Mr. RIECKEN. There are two things we do to try to accommodate the diversity and desirable variety of American educational interests. One is wherever possible to support more than one version, more than one curriculum group working on a particular subject. If you think States can disagree about how a subject should be taught you should see scientists. The other thing we do is to take every precaution we can to see that the materials that are produced make their own way on their own merit in normal competition with other materials. We do not subsidize the introduction of these materials into any school or school systems. We insist if the versions are sold commercially that they compete in price.
>
> Mr. EVINS. The Science Foundation makes a grant but then has no control over what results from the grant?

Mr. Riecken. We do not control the content and do not try to influence what is taught. We leave that in the hands of the professionals.

Mr. Evins. If X university or a certain educational group makes an attractive application to the Science Foundation for a substantial amount of money and says, "We need to upgrade our textbooks," you look at it with favor, and you may then allocate the money and what happens to it, you don't know, you assume it is upgraded and it is a worthwhile project and it is beneficial?

Mr. Riecken. Not completely, sir. We know pretty well what is done because we pay fairly close attention to these groups and read their progress reports and often are invited to attend some of their meetings and generally are sent copies of the trial versions.

Our interest, however, is not in affecting what the scientists and educators think should be taught about physics or about mathematics but only in how their product is marketed and advertised and introduced into the school system, into educational use. We refuse to permit Federal funds to be used for promotional purposes and we insist, as I said, that the commercial versions of the material be competitive with others in the market.

Mr. Evins. That is what I was driving at.[109]

D. FISCAL YEAR 1968—PRE-COLLEGE EDUCATION BEGINS TO BE REDIRECTED

The effects of the increased activity in Viet Nam were apparently beginning to be felt as the fiscal year 1968 budget request was being prepared, judging by discussions in the Senate appropriation hearings. However, budget preparation occurred in the fall of 1966, and apparently at that time President Johnson was still committed to his plans for the *Great Society*. The National Science Foundation was still able to request an increase of $46 million over the level of fiscal year 1966 and fiscal year 1967, during which the NSF appropriation had been static at the level of $479,999,000.

The appropriations hearings for fiscal year 1968 in both the House and Senate indicated a strong resurgence of Foundation interest in precollege education. The reasons are unclear, but this restoration of interest may have been the result of interplay between NSF and the Bureau of the Budget. In the appropriations hearings for fiscal year 1967, Dr. Haworth had mentioned that the education programs were undergoing a full program review. This review could well have been evidence of the programming-planning-budgeting philosophy which had originated in the Department of Defense as a tool for more effective management and which had been generally adopted by BOB in the mid-1960's.

Whatever the reason, the NSF budget submission for fiscal year 1968 was recast into an entirely new format and summarized by "category" (The word *objective* might have been more descriptive). Along with this, there emerged in the hearings a much more articulate discussion of the education programs, both as to their objectives and their operations, by Dr. Haworth and by Dr. John T. Wilson, the NSF Deputy Director.

The programming-planning-budgeting explanation would also seem to account for the strong fight that NSF made in its appropriations hearings to eliminate the minima that had regularly been stipulated in the appropriation acts for high school teacher training. In the 1960's the stipulated amount had come to be $37.6 million annually. The Foundation claimed that this prevented the shifting of funds to newer programs which had been devised to improve pre-college education but which dealt with schools and administrators rather than with teachers. Dr. Haworth's statement to the subcommittee in the House appropriations hearings read as follows:

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[109] Loc. cit. p. 205, 206, 207.

> Since fiscal year 1957 the appropriation language has included a specific proviso concerning supplementary training for secondary school teachers of science and mathematics. Over the years this limitation has focused a considerable part of the appropriation on various programs to supplement the training of individual teachers at the secondary school level. This type of program has been and will continue to be one of the more successful of the Foundation-sponsored programs. We feel that there is a need for a broader approach to the problems of improving the pre-college education in the sciences. Therefore, our proposal is made to change the language to include a proviso to provide $55 million for programs to improve the quality of pre-college education in the sciences and mathematics. If you will note on page 219 of the budget justification, this will enable the Foundation to distribute resources so that there is a better balance between improvement of course materials and the strengthening of the subject competence of teachers. A significant expansion is being proposed in the so-called Cooperative College School Program. This program is an effort to encourage greater cooperation between institutions of higher education which have a strong ongoing science education effort and selected local school systems. The objective of these cooperative programs is to accomplish a general upgrading in the quality of science and mathematics instruction within a school system with the thought that such cooperative efforts might serve as models for similar efforts to be supported either from local or State funds. To a considerable extent this program concept incorporates a number of the ideas discussed with the Committee on various occasions in the past. That is, the idea of devising programs which provide incentive through some financial support for locally devised self-improvement efforts. This program has been a relatively small one in past years. We feel that the results warrant the proposed expansion from $2.25 million to $7.25 million in fiscal year 1968.
>
> I hope the Committee will approve this broader and more flexible language. In the long run I believe that through the types of programs we are proposing, we can accomplish a more significant upgrading in the quality of pre-college education in the sciences and mathematics and that more teachers will be given the opportunity to strengthen their subject competence, although not through the more formal institutes technique.[110]

The testimony indicated that NSF was caught between congressional interest in certain of its established programs for high school teacher education—clearly strong interest in both the House and Senate—and the need to be able to demonstrate greater effectiveness to the Bureau of the Budget.

The Congress did not accept the idea that the minimum expenditure stipulation was in fact a restriction, since it seemed that there were adequate funds available for NSF's new programmatic objectives and since it appeared that NSF might want to actually divert funds from the high school programs. It retained the $37.6 million "floor" for the training of high school teachers. [111] However, the Congress did eliminate such wording in the appropriation act for fiscal year 1969.

Even though the new priorities and justifications were not helpful in obtaining an increase in the total obligations for science education in fiscal year 1968, they apparently did result in more funds for pre-college education. Whereas the total education obligation increased by about $1.5 million, the pre-college education obligation increased by almost $3.8 million; more than enough to erase the reduction of $860,000 the previous year. But fiscal year 1968 was to mark the last year of an all-time high plateau of support for science education at NSF—a budget level of about $124 million that had held for three years in a row. Fiscal year 1969 would produce a $10 million reduction in the obligations for pre-college education, with further reductions to come.

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[110] U.S. Congress. House. Subcommittee of the Committee on Appropriations. Independent Offices and Dept. of Housing and Urban Development Appropriations for 1968. Hearings, 90th Congress, 1st session. Washington, U.S. Govt. Print. Off., 1967. p. 181 ff.

[111] U.S. Congress, Senate, Subcommittee of the United States Senate Committee on Appropriations. Independent Offices and Department Housing and Urban Development appropriations for fiscal year 1968. Hearings 90th Congress, 1st session On H.R. 9960. Washington, U.S. Govt. Print. Off., 1967, p. 99 ff.

D1. CCSS Emphasizes Curriculum Implementation

It would appear that the NSF administration put a good deal of creative thought into the pre-college programs in preparing the fiscal year 1968 budget submission. In the House appropriations hearings, Dr. Haworth's prepared remarks went as follows:

> Turning now to education, I would like to just mention two broad generalities. One is that we have felt, as has been indicated earlier during Dr. Tyler's discussion, that we need to put more stress on the undergraduate level of support for education, and we are attempting to do that in a number of ways, which Dr. Fontaine will talk about. In addition to the College Science Improvement Program that I mentioned earlier, we are trying to expand on our support of curriculum development for undergraduate science—to give greater support to the commissions in the various sciences that are studying this question, as well as to the specific projects in this area. We want to emphasize still more the innovative types of things that are important at the undergraduate level such as the opportunity for undergraduates to do research, and various things of that sort.
>
> There is no marked change in the program with respect to the support of graduate education. We have requested some more fellowships and traineeships, but there is no sharp change in direction in any sense. On the other hand, at the precollege level, we are suggesting modifications in the program, primarily of the following sorts. In the first place, both through the precollege programs proper, and through the undergraduate programs we want to do more about trying to improve the precareer training, of high school and elementary school teachers. In the second place, and this is perhaps more drastic in its effect on the budget, we believe that we should put greater stress on attempting to find ways in which school systems can improve their teaching in the sciences.
>
> Our programs up to now have been very effective; for example the institutes programs have been very effective, and they should be continued, but they have not had the total impact on the schools or school systems that we would like to see, so we are requesting a very substantial increase in funds for such purposes, particularly the program we call the cooperative college-school program. Here a college or university arranges to assist the schools in its community, and in some instances, the whole State, to improve their science teaching. For example one college helps the school select from the many possible curricula, those that suit their circumstances best. It brings teachers from the various school systems in to the college, and helps them improve their knowledge of subject matter, and so forth.
>
> In other words, we are trying to help bring about a more focalized, concerted attack than results from the scattered types of things done in the past.[112]

D2. A Shift in Emphasis From Teachers to Schools

However, the Congress was beginning to be concerned about the overall size of the Federal budget for education and in the House appropriations hearings, Congressman Evins inquired about whether the activities of all agencies had been considered in preparing the budget request.[113] Dr. Haworth and Dr. Handler, who was then chairman of the National Science Board, assured him it had.

Thus assured about interagency coordination in budget planning, another major concern was raised: whether the shift of pre-college funds from institutes to the Cooperative College-School Science Program would mean that teachers would be selected differently for the summer programs. Dr. Thomas D. Fontaine, Associate Director (Education), attempted to respond:

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[112] Loc. cit. p. 191, 192.

[113] Ibid., p. 192, 193.

Mr. Talcott. Dr. Haworth said the institutes program before had been one of the more successful of the Foundation-sponsored programs. So here we will be changing one of the most successful programs. Before, it was an individual teacher-oriented type of a program, now we have a school-oriented type. Is this an effort to direct the thought of these teachers or control the philosophy of the teachers?

Dr. Fontaine. No, not in any way.

Mr. Talcott. What is the need for doing this?

Dr. Fontaine. First it should be clear that there will continue to be a reasonable opportunity for teachers to attend institutes. As I said earlier, the Cooperative College-School Science Program is a companion program to institutes—not a replacement program since the Foundation first began to support science institutes and to the present time, it has encouraged and supported the development of course content material and curriculum by groups of leading scientists.

It seems to us that the time has come when the Foundation can be more effective in certain cases by assisting the colleges and universities to work with the school systems in the introduction of the new materials.

Mr. Talcott. Have some of these teachers been too individualistic to satisfy you?

Dr. Fontaine. This question has never arisen to my knowledge.

* * * * * * *

Mr. Boland. You are making an effort to upgrade the quality of science and mathematics instruction on the local level by this cooperative program?

Dr. Haworth. That is right.

Mr. Boland. This is above and beyond what you have been doing with respect to the summer institutes.

Dr. Haworth. That is right.

Mr. Evins. There has been a lot of concern to have the local people involved rather than having direction and dictation on the guidelines from the Office of Education.

Dr. Haworth. If we could give two or three examples that are quite diversified: for example, the Madison project is a good one.

Dr. Fontaine. Let me make one other point. By moving to this cooperative college-school science program, it will be possible to effectively coordinate this activity with the support provided to school systems under title III funds administered by the Office of Education.[114]

The proposed shift of emphasis was large: the institutes were to decrease by $6.7 million and the CCSS Program to increase by $5.0 million. The subcommittee wanted to know whether there would be a change in the number of teachers involved in these programs:

Mr. Jonas. What I am trying to get at, and you can put the statistics in the record, is to show whether under this revised program in which you downgrade the institutes and upgrade the cooperative college-school science program, whether you are going to benefit more teachers or fewer.

Dr. Fontaine. In fiscal year 1967, we expect 36,000 secondary school teachers to participate. We anticipate with the funds requested for next year under these same programs that 39,716, an increase of over 3,000, will benefit. These data are given on page 223 of the budget. In total, under the precollege elementary and secondary school programs, we estimate that participation of elementary and secondary school teachers will increase from 42,241 in fiscal year 1967 to 56,605 in fiscal year 1968.

Mr. Jonas. Please break that down between institutes and this cooperative program. I think it is bound to show that fewer teachers will participate in the institutes.

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[114] Ibid., p. 217, 218.

Dr. FONTAINE. This is correct.

Mr. JONAS. I would like to know how many.

Dr. FONTAINE. It is shown on page 223.

Mr. JONAS. Read it into the record, please.

Dr. FONTAINE. Yes, sir. Academic year institute, 1,494 in 1967 and 408 in 1968. Summer institutes, 19,550 and 17,655, respectively.

Mr. JONAS. You mean down 2,000?

Dr. FONTAINE. Yes. In-service institutes, 13,636 and 13,453, respectively, or essentially no change. The cooperative college-school science program, 1,920 and 8,000, respectively, an increase of over 6,000, thus completely offsetting the earlier mentioned decrease.

Mr. JONAS. How can you do that with a total increase of only $3 million in this budget?

Dr. FONTAINE. Dr. Haworth mentioned that we believe the cooperative college-school science program is a less expensive program in terms of utilization and training of teachers. Local school systems are involved and there are contributions from the local school systems.[115]

The Foundation presented its own view of its current approach (in calendar 1966) to education in the budget submission for fiscal year 1968. This statement, which is printed below, provides a view of the context in which NSF was making decisions about its pre-college education programs. It also seems to substantiate the later reports from Foundation staff that the Bureau of the Budget, now OMB, was reluctant to approve programs which would provide continuing support to education. This alleged reluctance is said to account for the repeated budget and nomenclature revisions that have subsequently made the NSF education budget so confusing.

The NSF statement read in part:

* * * * * * *

Immediately after its establishment the Foundation undertook a critical examination of the status of education in the sciences with a veiw to discovering its major weaknesses and possible solutions thereof. That examination took the form of special studies and innumerable consultations with educators and scientists throughout the country and has continued to date to the extent resources of both funds and personnel permit. These studies resulted in the conclusions that:

many teachers of science at all levels were, for a variety of reasons, not adequately prepared in their subject matter to teach it effectively;

the quality of instructional materials—textbooks, films, laboratory instructional devices, and the like—were grossly inadequate; many were out of date and, frequently, excessively costly;

science-capable and science-oriented students were not being challenged by their schooling;

many educational authorities were either apathetic or actually antagonistic to the idea that substantial educational improvements were needed or feasible.

These findings became the basis of a program by the Foundation which sought to correct each of these conditions. The program has been developed on an evolutionary basis. Various ideas were converted into, typically, a few small, experimental projects and those which seemed to work well were, to the extent resources permitted, developed into relatively large activities. Others which proved not so effective or not feasible at a given time were dropped. From the beginning the Foundation has taken the position that since one of the principal weaknesses of science education was the fact that its content—the subject matter itself—was obsolete and dilute; teachers, books and students were expending much valuable time, space and effort upon inconsequentials and missing matters of importance. Hence, the Foundation attempted to secure the cooperation in a movement of national reform of the subject-matter experts, the practicing scientists, mathematicians and engineers who were also engaged in teaching. The idea has been that the scientific community should teach teachers, should help to give talented students' scientific experiences and instruction beyond that normally available in their regular schooling, should actively work in writing and producing better instructional materials and programs and, finally, begin to dig deeply into fundamental research on the teaching-learning process. The emergence of the subject-matter expert as a force in education was made a national policy and a practical reality. The concept and mechanisms have now spread beyond the realm of the sciences and into, in varying degree, all other disciplines.

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[115] Ibid., pp. 220.221.

One exceedingly important outcome of this movement has been the growing conviction on the part of educational authorities that improvement in all of education is both needed and feasibie. This has coincided with tht enactment, especially of the Elementary and Secondary Education Act and the Higher Education Act, both in 1965, of landmark legislation in American education. By virtue of these and certain other Acts (and amendments) the Federal Government is now committed to an unprecedented program of assistance to education. The programs authorized by the recent legislation are many and varied but the essential element underlying them is the principle of making funds available to State and local educational authorities to support the plans and projects of those authorities. Hence the conditions into which the Foundation's current educational programs were born and developed are changing rapidly. Accordingly, the Foundation has felt it desirable to re-evaluate all aspects of its educational programs and policies. The objective of this assessment is that of finding the ways in which the Foundation can convert its experience and other capabilities into a more effective contemporary role. Realizing, however, that drastic and abrupt changes in education are seldom wise, the Foundation is changing its programs step by step, but in fiscal year 1968 plans to accelerare its rate of change in the new directions.

Viewing the science education programs as a whole the planned changes in direction already begun—but to be hastened—are:

Relatively greater attention given to the academic strength of school systems and institutions of higher education.

According greater discretion to institutional authorities in the development of programs for improving their curricula, facilities, faculty competencies and student support programs.

Reducing, relatively, programs of support for the improvement of individual teachers in ways not necessarily relevant to the needs of their schools and colleges and especially for the unspecialized elementary school teachers.

Broadening the scope of the program to achieve a more desirable geographic distribution and a wider range of kinds of institutions eligible for support.

Giving heavier emphasis to improving instructional materials.

Increasing the extent of cooperation in international aspects of science education where these are fully consistent with and contributory to the implementation of the foreign policies of the United States.

Inherent in this trend is an increased focusing of the educational programs on education for careers in science and a gradual reshaping of the Foundation's role in general education. Also inherent is a decrease in the heretofore large, annually repetitive programs and an increased effort to innovate, to discover and test new ideas which, if useful, can be administered on a large scale in cooperation with other organizations or by other organizations. This general approach is designed to enable the Foundation to utilize to the greatest effect the flexibility given to it by its enabling legislation while keeping funding requirements to a minimum.[116] (Emphasis provided.)

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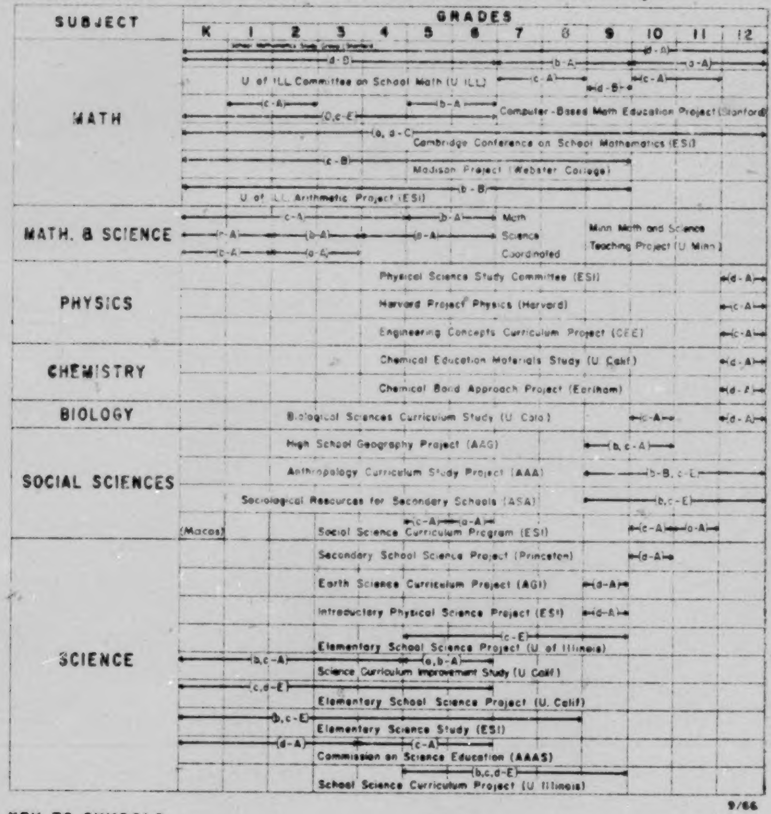
[116] Ibid., p. 363, 364.

D3. The Status of Curriculum Development in 1967

The status of the curriculum development effort in 1967 was presented to the subcommittee in graphic form:

PRINCIPAL CURRICULUM STUDY GROUPS PRE-COLLEGE EDUCATION IN SCIENCE



KEY TO SYMBOLS:

a	Planned or projected
b	Preliminary version
c	Extended trial version
d	Released for general use
A	Text and Supplementary Materials
B	Teacher Training Films and Course Materials
C	Guidelines for Curriculum & Course Development
D	Research in Learning
E	Unsequenced Units and Source Materials

CEE	Commission on Engineering Education
ESI	Educational Services Incorporated
AAG	American Association of Geographers
AAA	American Anthropological Association
ASA	American Sociological Association
AGI	American Geological Institute
AAAS	American Association for the Advancement of Science

These efforts would now become central to the NSF education program at the pre-college level. The content of one of these curricula would come to create a major problem for the Foundation.

E. FISCAL YEAR 1969—AN UNEXPECTED SETBACK

The Foundation requested a total appropriation of $500 million for fiscal year 1969. This, with a promised release of $27 million by the Bureau of the Budget from funds impounded under Public Law 90-218, would have allowed obligations of $527 million. The result was totally unexpected, for the Congress appropriated only $400 million—a 20 percent reduction from the level of fiscal year 1968. The reasons for this are barely indicated in the record of the appropriations hearings. However, a number of factors may have been involved, such as:

(1) The Congress was concerned with the size of the total Federal budget, which was threatening to pass the $200 billion mark.

(2) The Viet Nam War was costing enormous amounts of money, yet President Johnson was trying not to let this slow his domestic programs.

(3) The mohole failure may have left an impression of weak NSF management in the Congress. Its termination was still in process during the appropriations hearings.

(4) In a year when hard decisions had to be made to trim the budget, the Foundation was especially vulnerable for lack of appearing essential to any issue of immediate importance, in spite of its ability to show that other agencies were reducing research support in certain fields.

E1. PL 90-407 Provides Closer Relations Between Congress and NSF

The interest and sympathy of the Congress in NSF was indicated by the passage of Public Law 90-407, whose genesis had been the NSF oversight hearings in 1965 before the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics. This act created an extensive reorganization of the Foundation making its senior officers Presidential appointees; it provided for annual authorizations from Congress for its appropriation; and it required annual reports by the National Science Board to the Congress on the subject of the status and health of science in the United States. On February 18, 1969 the Board's first annual report focused on a topic of great interest to most of its members: graduate education. Two studies constituted the report:

(1) "Toward a Public Policy for Graduate Education in the Sciences," and

(2) "Graduate Education: Parameters for Public Policy."

Though a 20 percent reduction in total appropriation might seem to have justified an across-the-board reduction in Foundation programs, that did not actually occur. At the end of the year, the total education obligations were down less than 10 percent to about $115 million. Within that total, graduate education in science was reduced by about 13 percent; undergraduate education in science was *increased* by 27 percent while pre-college education in science was decreased by 17 percent. The table below shows the changes:

	Obligations	
	1968	1969
Precollege education in science	$54, 653, 538	$45, 497, 286
Undergraduate education in science	21, 513, 868	27, 334, 602
Graduate education in science	48, 665, 161	42, 465, 606

The increase in undergraduate programs was accounted for by the transfer to the Education Directorate of $8.76 million for the new College Science Improvement Program which had formerly been part of NSF's Institutional Directorate. The changes within the Pre-College Education in Science budget are worth noting as indicators of priorities:

	Obligations	
	1968	1969
Institutes	$34,224,727	$30,863,872
Course content improvement	13,307,243	7,924,535
CCSS	3,386,732	4,823,563
Science education for students	2,066,786	1,885,316
Research participation and scientific activities for teachers	1,234,972	0
Special projects	433,078	0

E2. Further Emphasis on Schools and School Administrators.

Since the Congress had deleted its mandated minimum expenditure for the training of high school teachers, NSF was able to effect a considerable reduction in that area without the complication of congressional restrictions.

In reporting on the events of the year in its Annual Report for 1969, the NSF said:

> Recognizing that effective use of teachers and new instructional materials in school systems requires the carefully planned assistance of science educators and supervisors, the Foundation substantially increased funds for the Cooperative College-School Science Program in fiscal year 1969. An encouraging feature of this support, evident in both the Cooperative College-School Science Program and the Academic Year and In-Service Institutes for Secondary School Teachers Programs, is that school systems are showing greater interest in, and making increased financial contributions to, these projects. In some instances, financial assistance has also been provided by industrial concerns.
>
> Academic Year and In-Service Institutes programs are now supporting a variety of projects aimed at developing specialists, coordinators, and supervisors with competencies directly relevant to school needs. Through the course content improvement program, continued and increased support is being given to workshop projects for training college and school resource personnel who are experts in the various new science and mathematics materials. The training is being conducted at a time when the new materials are beginning to be used extensively in the schools, and upon completion of training, these individuals will serve as leaders in In-Service and Cooperative College-School Science Projects. This kind of activity provides a direct link between the course development efforts and the teacher education and school implementation programs for improvement of science instruction.[117]

The Annual Report for 1969 went on to summarize the National need for improvement in science teaching and teacher competence as follows:

> While the quality of science instruction has been vastly improved through NSF-supported teacher training institutes and projects of the last decade, a critical need for continued supplementary training remains. Among the factors bearing on the problem are:
>
> science and mathematics curricula taught in the schools continue to be upgraded, due largely to the influence of NSF-supported course content improvement;

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[117] National Science Foundation Annual Report for fiscal year 1969. Washington, U.S. Govt. Print. Off., 1970. p. 78.

> school systems continue to employ not-fully-qualified teachers because the regular teacher-training programs of colleges and universities can supply only about 15,000 certificated teachers annually to fill 28,000 net vacancies covering expansion of science offerings and replacement of those leaving teaching:
>
> scientific research and scientific knowledge continue to expand and teachers are expected to keep their knowledge current;
>
> demands for trained science supervisors and other leaders in science education, needed to help implement the many school improvements resulting from massive Federal aid programs, continue to increase; and
>
> science teaching is being upgraded as a profession for which graduate training in subject matter is a requisite.
>
> * * * * * * *
>
> *The major trend in pre-college teacher education activities has been to increase substantially training opportunities directly related to the implementation of specific new courses. However, whether institutes focus on new curricular materials or traditional courses, increased emphasis on applicability of materials and implementation in the classrooms of the teacher-participants characterizes the institute program in general.*[118] (Emphasis added.)

Fiscal year 1969 witnessed a second revision in the budget organization of the education programs at NSF. This time, instead of structuring divisions according to the various levels of education, which would have coincided with the various divisions within the Education Directorate of the Foundation, the budget focused on three functional objectives:

(1) Student Development;

(2) Instructional Program Development and Educational Research; and

(3) Instructional Personnel Development.

(See Appendix A for Budget format.)

This would seem to have allowed various programmatic efforts to appear somewhat more as individual projects rather than as continuing programs.

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[118] Ibid., p. 81.

V. GREATER CONGRESSIONAL SCRUTINY OF NSF

In fiscal year 1970, the National Science Foundation began to receive greater attention from the Congress under Public Law 90-407, which provided for a full annual authorization of the NSF budget and which reorganized the Foundation to a great extent by the creation of four politically appointed assistant directors.

Prior to that time, the Foundation operated and thought very much as a private foundation might. It now became somewhat more political, although the Foundation still treads very carefully between (1) the interests and demands of the Congress; (2) the interests of the scientists whom it serves and who are heavily represented on its various boards and advisory panels, from the National Science Board on down; and (3) the interests of the Administration and the Office of Management and Budget.

There has always been a fear in the science community that science affairs might come to be dominated by politics. Basic science is often unpredictable, and needs to be free to respond to new findings and new ideas. Firm objectives seem to be out of place when entering totally unknown territory. On the other hand, by fiscal year 1970 the National Science Foundation had come to have an appropriation of almost half a billion dollars. Such magnitude demanded greater oversight by the Congress and more extensive justifications for NSF programs and activities. The total Federal research budget had become very large, and the total Federal education budget was also very impressive.

In the context of NSF's large size, and the large size of the total Federal programs with which its objectives were affiliated, it was understandable that Congress began to ask for more definite management of science and for better science information to produce more worthwhile results wherever possible. The same was true of education.

The Congress was apparently beginning to be concerned that many activities were being conducted by the Foundation for seemingly long periods of time without some attempt to assess their value or to apply the knowledge that had been gained. This congressional interest had been growing for a long time, as evidenced by repeated and increasingly frequent questions about (1) when the Federal research budget would level off; (2) what was being done to promote the dissemination of research results; (3) what the NSF was doing to promote progress in the social sciences, through which solutions to societal problems might be found; and (4) whether NSF was promoting applications of research, and whether it had authority to so so. (Under P.L. 90-407, NSF was given such authority.) Inquiry into these questions became deeper following the legislation providing for an annual authorization of NSF's budget.

The first two questions became a part of the continuing dialogue on how to manage science in the National interest, and are of perennial interest. On the other hand, NSF responded to the last of these questions, and to its new authority for applied research, by creating a new program that came to be called *Research Applied to National Needs*. Finally, in consequence of the congressional interest in the social sciences area, NSF created a Division of Social Sciences which sought to expand social science research along quantifiable lines.

Some of this congressional pressure apparently penetrated the education programs, for in the mid-1960's the Foundation began to fund curriculum development efforts in the social sciences. Though the interest in social sciences by Congress was directed at the research programs, it seems understandable that the education programs would respond. The first expressions of congressional interest in the social sciences came in the mid and late 1950's, along with considerable pressure from the social science community, and from professional organizations representing social sciences, for NSF to do more about social science research. Later, both the Kennedy Administration and the Johnson Administration sought to promote and to use the social sciences.

There was general agreement, it seemed, that the time had come to pay serious attention to social science research and education. Given this degree of interest from the public, from the Congress, and from the Administration, the Foundation had what amounted to a mandate to promote the social sciences. Later the National Science Foundation Act was amended to specifically assign NSF a responsibility for the social sciences in addition to other areas of science and engineering.

The focus on social and human problems of the Kennedy and Johnson years continued into the Nixon Administration, until the Viet Nam War and other problems brought such hopes and concerns to a standstill within the Administration.

Thus, fiscal year 1970 marked the beginning of an era when NSF was to be subject to much more Congressional scrutiny concerning its effectiveness in making its science and educational efforts be of definite benefit. This not only created many problems associated with having to procure certain identifiable results by applying research, but it also exposed NSF to the hazard of criticism resulting from the utilization of potentially controversial social science findings in applied research and in education.

A. FISCAL YEAR 1970—THE EDUCATION PROGRAMS ARE ANALYZED

Fiscal year 1970 was a point of change for the Foundation. Dr. Haworth's term as Director expired at the end of fiscal year 1969 and Dr. William D. McElroy assumed the position of Director after nomination by the President and confirmation by the Senate. McElroy was a dynamic person who promoted a good deal of reassessment of the NSF, but he was also a person whose interests do not appear to have been particularly inclined toward pre-college education, as related later in this study.

The NSF authorization hearings in the House for Fiscal Year 1970 were exhaustive and produced two large volumes of hearings records, one of testimony and the other of descriptive material from the Foundation.[119] In fact, they had much the character of oversight hearings, and provided a bench-mark statement of NSF activities.

One major interest of the subcommittee was in interagency coordination for the education programs. Dr. Thomas Fontaine, NSF Associate Director for Education, responded to Congressman Daddario's question about formal coordinative mechanisms by explaining that in October, 1964, Executive Order No. 11185, entitled *To Facilitate Coordination of Federal Education Programs*, had created the Federal Interagency Committee on Education (FICE). (Executive Order No. 11185, 29 F.R. 14399, Oct. 16, 1964 is reprinted in Appendix D.) Dr. Fontaine explained that FICE met every fourth Wednesday of each month to discuss common problems and to achieve coordinated action.

11. *Mr. Daddario's Concern About the Role and Function of the Institutes*

Mr. Daddario was also concerned about the First Annual Report of the National Science Board, which had focused on problems of graduate education. He made clear that he wanted to be sure that NSF was in a position to mobilize the attention of other, larger, agencies in dealing with this problem and that education programs were not being segmented into several parts:

> Mr. DADDARIO. The National Science Board Report, which places before us what seems to some to be an overwhelming challenge, does cause us to think more seriously and severely about the organization of these things so that there can be a more efficient use of monies. I wonder if we aren't leaning in the direction of splitting graduate education support from everything else below it? We have touched on this from time to time in the course of our discussions. How do you see that at this particular time?
>
> Dr. FONTAINE. Well, from my standpoint, I find it very difficult to visualize the role of the Foundation at only the graduate education level, because the foundation for science research potential begins much earlier. Unless some other agency can continue to provide support and guidance for the kinds of science education activities that we are now engaged in, it will be my strong recommendation that the Foundation should and must, if at all possible, continue to be involved in precollege and undergraduate education in the sciences.
>
> Further, I believe that at least——
>
> Mr. DADDARIO. You mean actually involved rather than through a coordinating mechanism which would keep you advised of what was going on in these areas so that programs could be made adaptable one to the other. So there must be coordinating mechanisms outside of your own involvements as you have already touched on.
>
> Dr. FONTAINE. Yes.
>
> As a matter of fact, we do have very close coordination with the Office of Education, on precollege and undergraduate science education programs.
>
> One of the key things that the Foundation has done is to involve leading scientists in the upgrading of science education. We feel rather keenly that this is something that should and must continue.
>
> We have involved the Office of Education in some of the training activities the Foundation supports. For example, in the NSF Cooperative College-School Science Program where we fund direct the costs of instruction the stipends for teachers have been paid from Titles 1 and 3 of the Elementary and Secondary Education Act, administered by the Office of Education. This is just one example.[120]

Then Mr. Daddario inquired into the effectiveness of the summer institutes. He inquired whether more effort should be put into pre-service training as opposed to the retraining of teachers already in service:

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[119] U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development. 91st Congress, 1st session. 1970 National Science Foundation Authorization. Hearings, on H.R. 4283 superseded by H.R. 10878. Volume I and Volume II. Washington, U.S. Govt. Print. Office, 1969.

[120] Ibid., p. 177.

> Mr. Daddario. But if this, after all, supplementary training, you are talking about teachers already in existence. My concern is that we are spending some $37 million-plus for this particular purpose in an area where a great deal needs to be done, there is no question about that. But I wonder if we wouldn't be better off spending this money in developing greater support for teachers in this area. Where we would start off with a better product in the first instance rather than to try to do over again what might not be able to be built-up despite these expenditures.
>
> Dr. Fontaine. Well, the very nature of science itself, evolving as it is, will require some of this type activity, for an extended period of time.
>
> Dr. Daddario. Retraining of teachers is just a small part of the retraining that we are going to need in the whole area of science activity.
>
> Dr. Fontaine. This is true.
>
> Mr. Daddario. But are we really dealing with the group which is most readily adaptable to increased activity to do a better job? Do the secondary schoolteachers fall into a special category? Are they that much better, or are they that much worse, so that we either do a better or a lesser job?
>
> Dr. Fontaine. Well, our position is that both need to be done. Some 10 years ago we would have had no real opportunity to do what we are now attempting to do, namely, launch a preservice teacher-training activity, for the simple reason that there was not as much communication as there is today between the departments of education or the schools of education and the science departments in the colleges. An even greater degree of communication is needed within the colleges. Ten years ago, when we first considered the need for better preservice teacher training, we received very little encouragement.
>
> As a matter of fact, it is only because of the involvement through the institute program that we now have come to the conclusion that there is a favorable climate within the colleges and universities whereby there is at least a possibility that through some of the programs that we are trying to support that there can be changes in the preservice training of the individual.[121]

Another aspect of effectiveness of the institutes programs was raised a bit later, bringing out further strengths and weaknesses of these types of efforts:

> Dr. Fontaine. You asked earlier about the priorities of the various institute programs. The academic year institute would fit into the priority order as a somewhat lower level than the summer or the in-service institutes or the cooperative college-school science program, for the simple reason that the academic year institute does two things immediately.
>
> One, the teacher is removed from the classroom for an entire year at least, whereas the summer, the in-service, the cooperative college-school science programs leave the individual in the teaching profession and therefore available during the academic year. The other factor is in terms of cost. Obviously, the academic year is more expensive than is any of the other mechanisms that we have talked about. We do consider these various aspects in our program formulation.
>
> Mr. Daddario. Dr. Kelson, do you have a point you want to make?
>
> Dr. Kelson. Mr. Chairman, you have touched on some extremely difficult questions which I will subsume under the term "the evaluation of educational activity."
>
> I used to be a scientist and I thought experiments were relatively easy to perform. But in this area. I find it is extremely difficult, to use the scientist's terminology, to control the variables. Summer institutes or other institutes for high school teachers for example, are intended to improve the teacher's qualifications, but with a view to improving what really happens in the classroom. The measure, therefore, of effectiveness is determined by what happens to the student of the teacher who participated in an institute, not so much by what happened to the teacher.
>
> How you can get some fix on what happens to the student and whether what happened is due to the teacher, new curriculum materials that were used, the tenor of the times, the attitudes of society—these become very difficult. I can

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[121] Ibid., p. 192.

> say, however, that several years ago we commissioned, through a contract, a study to see what were the effects in classrooms of teachers who had attended summer institutes and the effects of that attendance alone. This is what was found: attendance at one institute produced a measurable and salutary effect on the subsequent students of the teacher. If a teacher had attended two such summer institutes, the effects upon the students were enhanced, and in addition, the effects began to be visible on the teacher's colleagues. They were beginning to do things differently. If the teacher had attended as many as three summer institutes, there was a further reenforcement on the students; there was a reenforcement of the teacher's effect upon her colleagues. But, by that time, the teacher was becoming, in the eyes of the school administration, a specialist and was being used more and more to help design the programs of the school and so forth.
>
> Now, one of the problems that we have never solved is that, despite the nearly 10 years of rather large institute operations, approximately half of the eligible teachers have never even applied to attend any institute. We do not know how to reach this half. We do know that as a class they are, with many exceptions, the less effective teachers. They just don't care that much.
>
> I would also like to point out that for the high school science teachers there is roughly a 15-percent turnover each year—some generated by retirements, some by transfer upward to the junior colleges, and so forth. Thus, even at the comparatively large level of institute operations over the several years, there is still a large faction of the existing teachers in the high school classrooms who are still inadequately prepared and make no appreciable effort to do anything about it.[122]

Dr. Kelson was, at that time, Deputy Associate Director for Education at NSF.

A2. Contractural Arrangements for Curricula

One last important area of inquiry concerned contractural methods of handling material developed under the programs for curriculum improvement. The National Science Foundation submitted a copy of its policy memorandum dated February 6, 1969. This is reproduced in Appendix E for reference.

A3. The 1970 Appropriation

The House appropriations hearings for fiscal year 1970 produced little discussion of the NSF education programs. However, Congressman Giaimo reiterated that, "* * * I think this is one of your great programs", making his interest and encouragement quite clear. The Senate appropriations for fiscal year 1970 hearings did not discuss education to any extent. Of a total budget request of $497,000,000 in new obligations, the House authorized $477.6 million and recommended an appropriation of $418 million, while the Senate recommended an appropriation of $458 million. Conference produced an appropriation of $438 million, to which was added $23 million in unobligated funds held by the Bureau of the Budget for a total obligational authority of $461.2 million for fiscal year 1970.

A4. The PLATT REPORT: A Study of the NSF Education Programs

In calendar 1969, the National Science Board requested that the Foundation's Advisory Committee for Science Education undertake an evaluation of the NSF programs in education. The result, issued in March, 1970, was titled: Science Education—The Task Ahead for the National Science Foundation,[123] but is often termed the *Platt Report* in consequence of the Advisory Committee's chairman, Joseph B. Platt, the president of Harvey Mudd College. This report sought to represent both the positive and negative features of the NSF curriculum effort.

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[122] Ibid., p. 194, 195.

[123] National Science Foundation. Science education—the task ahead for the National Science Foundation. NSF 71-13. U.S. Govt. Print. Off. Washington, D.C. 1970.

The conclusion was that texts had been vastly improved as a result of NSF's efforts, and that "college-bound" students had profited. The influence may have been negative for high school students not so well adapted to going on to higher education, according to the report:

> What can be said about the use of materials developed under NSF grants? The concept of "use" at the undergraduate level does not have much meaning, partly because much of the emphasis here has been on coordination and stimulation of curriculum development efforts rather than on production of materials and partly because of pluralism in our colleges and universities. Some estimates, however, can be given for the secondary level. Of the 14,200,000 students enrolled in grades 9–12 in 1968–69, about 24 percent were using curriculum materials developed under NSF grants. This percentage represents an upper limit, since the project estimates are based on book sales, estimates of State educational agencies, and similar sources of information rather than a statistical survey of schools. Furthermore, some of the students take basic science and mathematics or social science during the same year. (See Table on p. 14.)
>
> The figures do not appear unreasonable, however, when compared with those taken from a survey made by the State Department of Public Instruction in Delaware. A questionnaire was distributed in late 1968 to all 36 high schools in Delaware.

ESTIMATE OF NUMBER OF SECONDARY SCHOOL STUDENTS USING CURRICULUM MATERIALS DEVELOPED UNDER NSF GRANTS IN THE 1968-69 SCHOOL YEAR

Project	Grade	Number of students
Biological sciences curriculum study (BSCS)	10	1, 500, 000
Chemical education material study (CHEMS)	11	500, 000
Introductory physical science (IPS)	9	500, 000
Earth science curriculum project (ESCP)	9	250, 000
School mathematics study group (SMSG)	9–12	250, 000
Physical science study committee (PSSC)	12	225, 000
Anthropology curriculum study project (ACSP)	9–10	50, 000
Chemical bond approach project (CBAP)	11	50, 000
Sociological resources for social studies (SRSS)	11–12	30, 000
High school geography project (HSGP)	9–12	11, 000
Engineering concepts curriculum project (ECCP)	12	3, 500
Total		3, 369, 500

Finally we come to the question of impact. In getting some measure of this "immeasurable" we have relied on our own personal knowledge, the replies to our letter-questionnaire, the NSF staff interviews, and the comments of the experts who consulted with us. In addition, with respect to impact at the undergraduate level, we have also had the benefit of an evaluation study on four College Commissions carried out by the Planning and Evaluation Unit of the NSF Education Divisions. The general picture we have obtained of past efforts is given below.

All of the NSF-supported pre-college projects have been improvements over past efforts in that they have succeeded in introducing excellent content into all of the courses developed. As a result, more students now enter college with better preparation in natural science and mathematics than did a decade ago. Those teachers able to handle the materials now have a greater sense of "disciplinary professionalism" than before. There has also been some progress in helping school systems to improve their understanding of science resources for general education and to use them more intelligently.

High school textbooks resulting from NSF-supported projects have served as models for those produced under different auspices. BSCS provides a case in point. Prior to 1960, two biology texts were extensively used; one sold over 60 percent of the market and the other, 20 percent. In the 1956 edition of the more popular of the two, the word "evolution" does not occur in either the index or text; there is no material on human reproduction, population genetics, modern coverage of ecology, cellular metabolism or molecular biology, little physiology, no significant coverage of microbiology, nothing on race, and little cognizance of the modern developments in subject matter in the first half of the 20th century.

> The treatment of the material is quite elementary, and there is no laboratory work integrated into the text and little of the process of science or inquiry approaches. The 1969 edition of this same text shows accommodation in almost every instance along the paths developed by the BSCS.
>
> From *The CHEM Study Story* [124] we quote the following: "It was found [in a May 1967 study] that of 10 new high school chemistry textbooks published between 1963 and 1967, five followed the general philosophy and content of CHEM Study with high fidelity. Three of the books were influenced somewhat by CHEM Study, as indicated by the inclusion of some up-to-date material on phases of matter, the mole concept, energy, rate and equilibrium characteristics of chemical reactions, and orbitals. Two of the ten were completely traditional in format and content."
>
> Similar statements can be made about materials produced by other projects. Furthermore the high school materials generated by NSF grants have also had effects on texts prepared for more advanced students. For example, in *SMSG: The Making of a Curriculum* [125] it is stated: "* * * Recently published textbooks for courses in mathematics for teachers, almost without exception, refer to the influence of SMSG in their contents. The same is true of newer books on curriculum and on methods of teaching mathematics. * * *" Another example is given by the following preface to the college chemistry text *Chemistry, A Study of Matter:* [126] "The text examines various topics, building on and adding enrichment to many of those presented in CHEMS, CBA, PSSC and BSCS programs. * * * Some of the great scientific ideas discussed are a challenging, maturing extension of those presented in the new programs of CHEMS and CBA as well as of PSSC and BSCS. * * *"
>
> Opinions vary as to which are the most successful of the NSF-supported projects, but it seems reasonable to conclude that some of the later starters, such as the Earth Science Curriculum Project, the Introductory Physical Science Project, the Engineering Concepts Curriculum Project, and the AAAS's "Science—A Process Approach" have been able to profit from the pioneering efforts—and mistakes—of the early starters. Less progress has been made in the social sciences and far less in interdisciplinary efforts to relate the natural sciences to each other, the natural to the social sciences, and mathematics to both. Nor has there been effective articulation in most cases between the grades and levels of education.
>
> There seems little doubt that the benefits for bright, science-oriented, college-bound students have been appreciable. On the other hand, there are strong indications that the benefits for the less bright, disadvantaged, or even bright, non-science-oriented students have been significantly fewer and perhaps even negative in the sense that the more difficult courses have "turned off" these students. Several reasons may be advanced for this differential effect, but an important one seems to be the fact that the prime movers of the projects have been university scientists and mathematicians with the desire (unconscious, at least) to further their own disciplines. Another reason is that the first products—PSSC, CHEMS, BSCS and SMSG—were specifically designed for the students then taking the established high school curriculum, a subgroup which, by and large, was made up of science-oriented college-bound students. It is not surprising that these courses have been more successful for the students for whom they were intended.
>
> At the junior high school grades and below, the differentiation between poor and good students is no more evident in the use of the new curriculum materials than with any other materials. In these grades the target students are the entire student population, and the materials have been developed and tested in representative classrooms so as to be applicable for the entire student population insofar as that can be done. In the early elementary grades in particular the stage of the child's development as well as the subject matter has been, and must be, taken into account in selecting, organizing, and presenting teaching materials.

The report made a number of recommendations. One was to the effect that:

> One of the most prevalent and recurring themes in the Committee's investigation concerned the need for grants to educational research projects modeled on the more modest sized grants made by the Research Divisions of the Foundation. * * *

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[124] Richard J. Merrill and David W. Ridgway, W. H. Freeman and Company, 1969, p. 69.
[125] William Wooten, Yale University Press, 1965, p. 137.
[126] A. B. Garrett, W. T. Lippincott, and F. H. Verhoeh, Blaisdell, 1968.

> *Accordingly, the Committee recommends the making of grants wherein one faculty member (or a small number of faculty) at a single institution, together with students who are candidates for doctoral degrees in science education (either through Schools of Education or science departments), are supported for their research in science education.*

Among the next recommendations were:

> *1. The Committee recommends continued support of institutes for teachers as long as a significant percentage of new participants can be attracted and as long as subject matter is genuinely upgrading.*
>
> Having made these recommendations, however, the Committee, recognizing the realities of budgets, cannot help but be alarmed at the inevitable restrictions on support by the Foundation for creative research in science education, if it projects for itself a major responsibility for the training of school teachers.
>
> *2. The Committee recommends therefore that in teacher training, as elsewhere, the Foundation limit its role to innovative efforts.*
>
> *3. The Committee recommends first that course content improvement programs still in progress—what we may term "first generation" attempts—be supported to their conclusions.*
>
> The feeling among the leaders in course content improvement is that first generation attempts should be followed, not by second attempts at doing the same things, but by precedent-setting attempts to solve key curriculum problems. Courses need to be developed which are relevant to the interests of the students and society, but at the same time capable of preparing the college-bound, science-oriented student for undergraduate work. These must take into account the range of abilities, backgrounds, and varying vocational interests of children and young adults. If this requires more than one kind of approach, then different approaches should be supported, so that all students graduating from high school will be equipped to live in a technological world. Our citizens should be as literate with respect to science and technology as with the traditional three R's.

And finally, the Report turned to several problems that were to be of special interest in the future. One of these dealt specifically with the social and behavioral sciences:

> Social and Behavioral Sciences. The Committee calls attention to Chapter VII of *Knowledge Into Action: Improving the Nation's Use of the Social Sciences.*[127] This report calls for a new direction of Foundation effort in recognition of the understandings and insights of the social sciences, their role and application to the problems of American society, and their particular needs as these disciplines assume their new roles in the Seventies.
>
> In the pre-college area there is a dual reason for emphasis on support of the social and behavioral sciences. First, the understanding needed of the processes of education of the young, and second, the communication to the young of the content and spirit of these disciplines.
>
> The Committee recommends greatly increased support for the social and behavioral sciences with particular emphasis on the area of pre-college education.

The possible transfer of the pre-college programs to the Office of Education was another area of concern to the Platt Committee:

> The Foundation's activities in science education try to take into account programs and plans of the Office of Education insofar as they are known. There is, at present, coordination between the two agencies on a number of projects and in specific program fields, for instance, teacher training. Relationships and interaction between the staffs have been amicable and helpful; several members of the Foundation program staff serve on advisory councils and panels of the Office of Education. Recently, the two agencies have initiated discussions to arrange, on a limited basis, exchange of individual staff members.
>
> *There is, however, no general agreement on the related roles of the two agencies in the field of science. By congressional and executive decision, the Office of Education has the major responsibility for administering Federal support extended directly to schools and school systems at the pre-college level, particularly in regard to funds apportioned on various formula bases. The Foundation is authorized to further the quality and quantity of science education, which of necessity will involve some efforts for the lower schools. However, comparative funding of the two agencies reflects a major role for the Office of Education in the lower schools and a minor role for the Foundation.* (Emphasis added.)

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[127] Report of the Special Commission on the Social Sciences of the National Science Board, 1969.

> There are those who generalize to say that any Federal responsibility for science instruction in the lower schools should be assumed by the Office of Education and the Foundation should limit its educational efforts to the undergraduate and the graduate levels. Others feel that the Foundation should continue its instructural improvement efforts, its pilot programs, its development of instructional materials, and model implementation efforts, leaving to the Office of Education responsibility for mass dissemination of such ideas and materials as are appropriate. There is danger within the present confusion and potential misunderstanding of roles that the research and development effort in science instruction in elementary and secondary schools may be lost between the two agencies. It has certainly been true that, in recent years, the Office of Education has not had funds available to support the kinds of projects that the scientific community and the Foundation staff have deemed crucial to continued improvement of science education at the pre-college level. *The sheer size of the Office of Education's responsibility is such that the Foundation should have continuing concern for the nature of science education in U.S. schools. There should be no thought of abandoning its present roles in elementary and secondary education unless and until it is assured that continuing concern with the upgrading of the science component is being handled in an appropriate manner through alternate programs.* (Emphasis added.)
>
> *In statements received by the Committee it was apparent that the style and prestige of the Foundation is an important factor in any assignment of roles in science education in the elementary and secondary schools. The ability of the Foundation to attract major scientists and scholars to work on problems and to develop materials has been a distinguishing feature of its work of the past decade. It is important that this interest and effort on the part of the scientific community be sustained.* (Emphasis added.)
>
> We therefore recommend that the Foundation continue its support of research and development in pre-college science education, with appropriate strengthening of liaison between the Foundation and the U.S. Office of Education at all levels of operation to assure working understandings and appropriate interaction between the two agencies.

On the other hand, the Report registered frustration about the failure of schools and colleges of education to provide more adequate training in science for teachers at the undergraduate level. The committee's recommendation was vigorous, but the report did not indicate the committee's careful examination of how this presumably extensive science instruction would be fitted into pre-service teacher-education curricula without sacrificing other important areas of instruction. To quote the Report:

> Without a well-trained corps of elementary and secondary school teachers we cannot hope to impart to pre-college students the kind of education and attitudes in science that this report calls for. Much can be done with institutes and other postgraduate education to assist in the preparation of teachers. Yet much of this is, admittedly, a "retread" job. The primary place to educate the teacher is in his pre-service training. The Committee believes the Foundation has a fundamental responsibility to upgrade the science education of teachers through any and all mechanisms.
>
> Accordingly, we recommend that programs be developed and supported for dramatically increasing and improving the science component in the pre-service training of teachers.
>
> This attempt will meet with enormous resistance both passive and active on the part of professional educators and Schools of Education. This resistance must be overcome and the cooperation of all sectors must be obtained through conferences, interagency cooperation, and all other means of communication. This most critical problem must not go unsolved because of traditional hostilities and rivalries in our institutions.

A5. A Few Questions Raised by the Platt Report

The committee's failure to specify (1) the level of mastery of science that would be needed and (2) the requisite program if instruction in science to properly equip pre-college teachers to gain that level of competence, would not seem to have justified such a recommendation. Nor does this recommendation reflect the tenor of the committee's discussion, earlier in the report, about the impact and role of the institutes' program:

> The importance of the role of the teacher in achieving the maximum potential of new courses cannot be overlooked. Nor can the contribution made by NSF-supported institutes in equipping teachers to handle new materials. It is not our intention to go over the ground covered so well in *An Investment in Knowledge*, the study of the first dozen years of the Institute Program. It might be well, however, to mention some of the findings reported by that study. For example, it is known that through 1965 approximately 150,000 "training opportunities" for teachers had been provided through institutes, and it is believed that about a third of the estimated 226,000 people teaching science and mathematics in 1964–65 had been to at least one summer institute. On the other hand, it was reported in a study conducted during the 1961–62 school year that more than half of the science and mathematics teachers in the Nation's high schools had not submitted an application to any institute during the previous 5 years. Despite this seeming underutilization of the institute mechanism for improving teachers and the failure of institutes to stimulate a genuine reform in their pre-service training, Dr. James B. Conant in his 1963 book, *The Education of American Teachers* stated that "the use of [NSF] summer institutes for bringing teachers up to date in a subject-matter field has been perhaps the single most important improvement in recent years in the training of secondary school teachers."
>
> What about the specific relationship between course and curriculum improvement and teacher institutes? Some questions from the Krieghbaum-Rawson study are of interest in answering this question. Dr. Jerrold R. Zacharias: "The National Science Foundation-sponsored PSSC summer and in-service teacher training institutes have been an essential part of the overall PSSC physics program. They perhaps more than any other single influence have helped make the course immediately useful to teachers and students. * * *" Dr. George C. Pimentel: "I believe that chemistry teachers with strong background in content can teach CHEMS without too much retraining, but the average teacher probably would be well advised not to undertake this change without retraining. This is where the Summer Institutes play their vital role." Dr. Max Beberman: "Without the NSF Summer Institutes, any widespread inauguration of new curriculum reforms would be most difficult—if not impossible."
>
> The opinions of our questionnaire respondents regarding the value of teacher institutes varied widely. One attributed a large part of the success of PSSC and CHEMS to good teacher training and the ready availability of the combination of texts, films, and laboratory equipment, Another found the quality of instruction in individual institutes to vary considerably and suggested a raising of standards even if that meant reducing the number of institutes and increasing the number of participants in the good ones. Others found institutes to be doing a good job in increasing the subject matter knowledge of teachers, but a poor one in improving pedagogical techniques.

The reported failure to attract 50 percent of high school science teachers to the institutes program has been an oft-quoted statistic in NSF's attempts to demonstrate that the institutes have reached a point of diminishing returns and that they should be replaced by very different programs. The Platt Committee seems to have accepted this 1961–1962 statistic at face value, and failed to inquire (1) whether the statistic was still valid in 1970 and (2) whether a 50 percent response was an indication of continuing success in the steady state for a program that depended upon the individual initiative of teachers to apply. In fact it would have been incorrect to have inferred that institutes in 1970 were populated primarily by teachers who had attended year after year. Certain members of the NSF staff undertook an unofficial study in 1970 of prior institute attendence by participants in summer institutes held in 1970. After subtracting the number of teachers who had previously been enrolled in degree granting programs that required attendance at a series of institutes over a period of several years, and were thus returning for further study under a definite sequenced program, *it was found that 63 percent of the participants were seeking to attend an institute for the first time.*[128]

Number of previous summer institutes attended	Number of participants in 1970	Percent of participants in 1970	Number of prior participations
0	8,600	45	0
1	4,200	22	4,200
2	3,000	16	6,000
3	1,900	10	5,700
4	900	5	3,600
5 or more	400	2	2,200
Total	19,000	100	21,700

"Of the 19,000 participants last summer, 5,400 were returnees to Sequences in which they were already in midstream. The remaining 13,600 were Sequence entrants or were Unitary participants; 5,000 had participated in at least one previous institute, but 8,600 were first-timers. In other words, of the 13,600 individuals for whom the selection decision was made in 1970, *63 percent had never participated in a Summer Institute before.* The average number of prior participations for *all* participants (including Sequence returnees) was *1.14.*

"*Note added in January 1975.*—Data regarding prior participations were not recorded for the Sequence returnees separately from those participants for whom the selection decision was made in 1970. However, calculations based on reasonable assumptions indicate the average number of prior participations to be in the range 2.1-2.3 for the 5,400 Sequence returnees, and in the range 0.7-0.8 for the 13,600 participants for whom the selection decision was made in 1970. As indicated above, of those selected in 1970, 63 percent had never participated in a Summer Institute."

Thus the institutes would seem to have been reaching a good many new people in 1970. But this statistic does not seem to have appeared, nor has a thorough statistical study and analysis of the institutes been reported subsequently.

Since the Platt Committee had failed to specify the extent and nature of science training that might be feasible during pre-service teacher education, it was difficult to assess from the report what sort of role the institutes might play, or ought to play, even had pre-service science training been able to be improved. Thus the committee's recommendations did not seem to provide an adequate basis for changing the institutes program.

The Platt Report made no mention of any effort on its part to assess the implications or the policy considerations relating to recent changes in direction of the Foundation's pre-college education programs. The committee found that the NSF staff were operating in a passive mode, and urged that more staff be added to reduce individual work loads so as to allow for more creativity:

> We have examined the working styles of the staff of the Education Divisions and found them to be limited largely to a passive or reactive role to ideas generated from the field. In our judgment, the role and style of the working staff should of necessity become more active and less passive. The staff must seek out, and seek out *in the field*, promising directions of development, identify the competent men of science and education, open new frontiers, assess weaknesses and, with the aid of "judgment by peers," select and fund those efforts that will define, shape, and further the expanding roles of the Foundation.
>
> We therefore recommend that the staff be encouraged to assume a more active role in the field and to seek out promising directions, promising men, and promising institutions both to define and to carry forward the work of the Foundation.
>
> Budget allocations for the science education effort are not only inadequate for present responsibilities but need major increases to accomplish additional roles and reach new goals. In our judgment, this is a key limitation in the educational effort and may be true throughout the Foundation. The inadequacies become most apparent operationally in staffing and staff travel. It is the Committee's judgment that staff limitations and actual cutbacks have weakened staff morale

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[128] The full text of the memo summarizing the results of the study is as follows:

"*Prior Attendance in Summer Institutes, March 1971.*—We have recently completed a tabulation of numbers of Summer Institutes previously attended by teachers who participated in Summer Institutes in 1970. The distribution according to numbers of previous participations is summarized below:

> and produced serious overloads. More importantly, staff and travel limitations have almost eliminated the needed outside contact and have seriously limited the outreach of the Foundation. If the Foundation is to assume an active leadership role and to break out of its isolation from the scenes of action, the matter of staff and staff travel will have to be met much more effectively than at present.
>
> A program of sabbatical leaves and exchanges between staff members and members of university faculties, research laboratories, State departments of education or higher education, and the business-industrial community is needed. Certainly, the level of professional experience and continuing performance required of many Foundation staff members justifies these practices and for the same reasons that these are justified for corporation middle-management, college professionals, research staffs, and others. Failure to provide such opportunities for renewal and upgrading takes its toll in fatigue and isolation from professional contacts and the research laboratory, all of which contribute to rapid turnover.
>
> We are aware of directives from the executive branch of the Government to hold down expenditure, the reduction in force by nonreplacement, and the limitation of new ventures and reduction in level of funding of many current commitments in the interest of cooling the economy. However, it is assumed that these restrictions are relatively temporary. The problem of budget for the Foundation is of much longer standing. Part of the problem results from a limitation clause placed on appropriations which commits a major portion of the funding of the Education Divisions to teacher education. We urge review of the whole Foundation budget in terms of priorities and programs.
>
> Some of these arguments may be appropriate for inclusion in future fiscal year budget requests. For example, it is estimated that to change the image of the Foundation from passive to active agent, the budget for staff and travel would need an increase of approximately 50 percent. Travel allotment needs to be related to the function. Some programs involve many small grants widely scattered. Other programs need extensive developmental work in the field. And for all areas there is need for contact and visitation to identify and encourage new leadership in science.
>
> We therefore recommend that the Foundation review its efforts to seek adequate funding of staff and staff travel sufficient for present programs as well as for the expanded role recommended in other parts of the report.

However, the committee failed to look for factors other than work load, such as policies and practices of the Foundation which might have encouraged or required this passive role. Nor did it examine the Education Directorate's methods of proposal evaluation, its grant-making procedures, or its post-hoc evaluation procedures. It therefore did not consider a number of factors which would lead to serious questions of management in 1975.

Though the Platt Report had shortcomings in its depth of analysis, it had expressed an independent viewpoint that was sympathetic to the retention of a strong pre-college education program at NSF and to the maintenance of the institutes as long as they could serve a vital function. But it could not be claimed that the committee was protecting the pre-college programs out of self-interest, for its members were not from backgrounds that would seem to have produced a bias in favor of these activities. The members are listed below for reference.

Advisory Committee for Science Education—1969

Sanford S. Atwood, President, Emory University, Atlanta, Ga.
George Henry Baird, President and Executive Director, Educational Research Council, Cleveland, Ohio.
Lionel V. Baldwin, Dean, College of Engineering, Colorado State University, Fort Collins, Colo.
Herbert J. Greenberg, Chairman, Department of Mathematics, University of Denver, Denver, Colo.
John K. Hulm, Director, Solid State Sciences R. & D., Research Laboratories, Westinghouse Electric Corp., Pittsburgh, Pa.

Allan A. Kuusisto, Vice President for Academic Affairs, State University of New York, Albany, N.Y.

James W. Mayo, Chairman, Department of Physics, Morehouse College, Atlanta, Ga.

James Findley Nickerson, President, Mankato State College, Mankato, Minn.

Joseph B. Platt (Chairman), President, Harvey Mudd College, Claremont, Calif.

Arnold E. Ross, Chairman, Department of Mathematics, Ohio State University, Columbus, Ohio.

William A. Stallard, President, South Florida Junior College, Avon Park, Fla.

A6. Topics of Particular Interest in the 20th Annual Report

The Foundation described some of its major activities in pre-college education as follows in its 20th Annual Report:[129]

> Through the Division of Pre-College Education in Science, the Foundation administers programs for the development of scientific talent, the supplementary training of teachers, and the improvement of school science programs for all students. By far the largest portion of funds available for this level, nearly 75 percent in fiscal year 1970, is devoted to in-service training for secondary school teachers and supervisors through the various institute programs. These programs cover all the scientific disciplines and include a broad range of activities from short briefing conferences on new teaching materials to intensive studies during the academic year and/or adjacent summers. Nearly 50,000 individual teachers and science supervisors will participate in institute programs during the summers and academic year of 1970–71.
>
> In addition, about 6,300 elementary and secondary school teachers will receive in-service training through Cooperative College-School Science (CCSS) projects. The primary objective of CCSS is the effective introduction of new teaching materials and methods in a school system or related group of schools through a plan developed jointly with a university whose staff then helps with implementation.

On pages 71 and 72, the Annual Report told of some unusual problems in developing its social science curricula:

> The social sciences represent a major curriculum area in which development of suitable materials has lagged rather far behind that for mathematics and the natural sciences, with large gaps over the whole kindergarten to 12th grade range. Because there is no discernible consensus as to what an integrated sequence might be, the Foundation has supported the development of specific high school courses in geography and sociology, and of supplementary materials in sociology and anthropology for use in social studies courses. An interdisciplinary effort was initiated this year, led by Dr. Irvin De Vore of Harvard, to create a behavioral science course for the intermediate level on the general theme, *Exploring Human Nature*.
>
> At the elementary level, an innovative 5th grade course neared completion in fiscal year 1970. This course, *Man—A Course of Study*, is based on three questions framed by Jerome S. Bruner, the principal developer: "What is human about human beings? How did they get that way? How can they be made more so?" The first half of the course concentrates on the life cycles and behaviors of salmon, herring gulls, and baboons. These studies lead students to assess the significance of generational overlap and parental care, innate and learned behavior, group structure and communication, and their relevance of the varying life styles of animal species, including the human species. The second half of the course is an intensive study of man in society—as culture-building, ethical creatures, toolmakers and dreamers. The Netsilik Eskimos of the Canadian Artic are studied in depth, because their society is small and technologically simple, yet universal in the problems it faces. Course materials rely heavily on research sources and present subject matter through a variety of media, including films, filmstrips, records, posters, and booklets.
>
> This project posed an unusual distribution problem. Although the teachers and children involved in the trial phase of the development were enthusiastic about the course, commercial book publishers and film distributors were unwilling to contract for publication because of the variety of materials to be handled and the unconventional subject matter. Support therefore was made available to the sponsor, on the basis of a revolving fund award, to conduct a quasi-commercial

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[129] National Science Foundation. Twentieth Annual Report for the Fiscal Year Ended June 30, 1970. U.S. Govt. Print. Off., Washington, D.C. 1971.

publication and distribution operation to demonstrate the general public acceptance and the commercial feasibility of distributing the materials. The success of this venture is attested to by the fact that a publication contract has recently been executed with Curriculum Development Associates. Further implementation is being aided through the development of resource teams in teacher training institutions and through cooperative college-school science projects.

The course by Bruner, *Man—A Course of Study*, would become a major issue in the authorization and appropriation hearings for fiscal year 1976.

In terms of fiscal obligations in fiscal year 1970, there is some indication that NSF heeded Congressional interest in the institutes for pre-college teachers. With an increase in total funds for education in science of about $5 million, to a total of about $120 million, the Foundation increased the pre-college institutes budget by about $6 million to a total of over $36.9 million. This was partly compensated by a reduction in curriculum development and CCSS of roughly $1.5 million to a level of about $11.2 million. The other category, Science Education for Students, stayed approximately constant at about $1.9 million. The result was an increase of about $4.5 million for pre-college education, bringing the FY 1970 obligation to about $50.0 million which was about $5.0 million below FY 1968.

B. FISCAL YEAR: 1971 NSF CUTS PRE-COLLEGE INSTITUTES

By March, 1970, when the NSF appropriation was being considered in the House, the Foundation was apparently trying to deal with some difficult matters not of its own making. University students were raising strenuous objection to the Viet Nam War, and to the military-sponsored research being conducted on the Nation's campuses. The Mansfield Amendment, limiting the sponsorship of research by the Department of Defense to projects which had "a direct and apparent relationship to a specific military function or operation," seemed to NSF to threaten the termination of support of considerable amounts of basic research and thereby to thrust an impossible demand for support on the Foundation.

Research was under criticism, so it seemed; and as the hearings opened in the House, it was clear that Dr. McElroy and Dr. Handler were concerned about where events would lead. They predicted that the Mansfield Amendment would produce an avalanche of proposals from scientists formerly supported by the Department of Defense; proposals that might literally inundate the Foundation's resources. The subcommittee chairman did not share their alarm:

> Mr. Evins. . . . .
>
> I wanted to allude to one other matter. Do you not think the military will be able to find some way to say that science is related to defense?
>
> Dr. Handler. They have to do it on a project-by-project basis according to the language of that action.
>
> Mr. Evins. They are smart enough and ingenious enough that they will find their research projects are all science and defense related.
>
> Do you have any example of the Defense Department referring any matters because of this amendment or other actions to the National Science Foundation?
>
> Dr. Handler. Yes, we do, sir. I am sure Dr. McElroy will speak to that.
>
> Mr. Evins. Take two or three. Just tell us what the Defense Department said that they want you to do now.
>
> Dr. McElory. They have said, "We are dropping the following projects."
>
> Mr. Evins. You gentlemen don't really feel the Defense Department will cut back on their research in scientific matters, do you?

> Dr. McElroy. Yes, sir. They are going to have to, unfortunately, I agree with Dr. Handler, it is unfortunate that they are.
>
> Mr. Jonas. As I read the papers, the college administrators are surrendering to a vocal minority on the campuses and they are trying to drive the defense activities off campus.
>
> Dr. McElroy. I hope you saw the papers this morning in which the University of Chicago was greatly commended for expelling or suspending a few students and trying to get things back into order. I think you will see the same thing happen in other universities.
>
> Mr. Jonas. We should leave room in there for people who want an education.
>
> Dr. McElroy. There are programs like Haystack and MIT, for example, which DOD is dropping.
>
> Mr. Evins. We want you to mention those as we go along.
>
> Dr. McElroy. We have already been informed by the Department of Defense of dropouts amounting to the order of $50 million plus the other agency dropouts that Dr. Handler is talking about. For example, NIH no longer feels they can support certain areas of organic chemistry. We think it is very fundamental. They also feel they cannot support the area of photosynthesis. I want to point out to you, Mr. Chairman, that photosynthesis produces all the oxygen in this world that we breathe. If photosynthesis is reduced by pollution in the oceans and estuaries and by the contamination on the surface of this earth, I submit to you that will be a health problem such as never seen before. We had better start learning how to live aerobically.[130]

Though the sort of disaster predicted by Dr. Handler and Dr. McElroy did not materialize (at least trouble did not appear in such a short time that important adjustments could not be made), the situation did divert NSF attention away from education.

Another disconcerting event that seemed certain to affect attitudes toward science education was a slackening of demand for scientists:

> Mr. Jonas. I would raise one other question and then I will subside. This is appropos to the comment about graduate work.
>
> I think Dr. Handler said in his opening remarks that there was some slackening in demand for graduate studies or students.
>
> Dr. Handler. We haven't experienced it yet, but the current crop of undergraduate students indicates that will happen. Considering the current level of undergraduate majors in the sciences, it is quite possible that we will experience a diminution in students coming into graduate school in 2 years.
>
> Mr. Jonas. May I read you a sentence from the February 17 issue of the Wall Street Journal:
>
> "Total demand for Ph. D.'s is off about 25 percent from last year, Michigan State University reports."
>
> How do you account for that?
>
> Dr. Handler. The Federal funding level, sir.
>
> Mr. Jonas. No; I mean the demand. Do you mean we have been producing more Ph.D.'s than industry and education can absorb?
>
> Dr. Handler. No, sir. The National Academy of Science at my request, in December, instituted a study to determine whether we have or have not been so doing. We have examined what happened to the Ph. D. graduates of the classes of 1968 and 1969 to see where they are. And they are not unemployed. All of them are finding employment. Not all of them are working where they had hoped to, and I think that is the real crux. It gets us back to what Mr. Picker was saying to you a while ago.
>
> It is true that there is a tendency for young people who do their graduate study at great universities to seek positions in similar situations and they are disappointed, some of them, in the fact that those institutions may be reaching saturation. But we really said to you many years ago, sir, that our hope was that one day we would produce enough capable scientists to staff not only those great universities, but the middle-size universities, the liberal arts colleges, the community colleges, the laboratories of industry, and the laboratories of government. That is what we are now doing and I think that is success, not failure. But they are not unemployed. The demand is down 25 percent, but that is because there were many more jobs than there were people until very recently

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[130] U.S. Congress. House. A Subcommittee of the Committee on Appropriations. Hearings, 91st Congress 2nd session, Independent Offices and Department of Housing and Urban Development Appropriations for 1971. Washington. U.S. Govt. Print. Off., 1970. p. 571.

Mr. JONAS. Now, there are more people than jobs?[131]
Dr. HANDLER. Not yet.

B1. A Major Reduction for Institutes

Perhaps in consequence of this change in demand, perhaps because of some of the statements in the Platt report, or perhaps because of the need for research funds, Dr. McElroy undertook a major reorganization of the Education Directorate's programs in fiscal year 1971. Mr. Evins inquired into the matter:

Mr. EVINS * * *.

At the graduate level, financial support for students in the form of fellowships and traineeships is to be lessened?

Dr. MCELROY. Yes, sir.

Mr. EVINS. This is the area in which you are going to have less funding for traineeships?

Dr. MCELROY. Yes, sir.

Mr. EVINS. There is also a decrease for the institute program to develop teachers in sciences and mathematics. This the area where the committee has earmarked funds in the past. The Science Foundation now thinks that teachers and students are doing so well that they can deemphasize just a little bit. Are you going to continue the program at a slightly reduced level?

Dr. MCELROY. It is not just slightly reduced. I must be honest and say that in the proposed fiscal year 1971 budget it is considerably reduced in the precollege institute program. As I indicated briefly, the main thrust of our science education program for students and the training of teachers has been directed at reaching the 20 percent of students who would be science majors. We feel we must take time this next year to reorient our science education program toward new curriculum for the other 80 percent of the students and training strategy for high school teachers to meet this need. For that purpose, we just need a little time. We don't believe we can gear up to spend additional money in that direction this coming year.

As I indicated in my brief talk, this is one of the most critical reappraisals that our educational group has ever gone through. They have been one of the most innovative groups in the Foundation and, if the opportunity presents itself during these hearings, I would like to show you our tentative plan through 1975 to really do a first-class job.

Mr. EVINS. The committee has observed that the institutes program has been most effective in stimulating the enthusiasm and capability of teachers. They are always in the front line teaching the students. Does HEW have a similar kind of program?

Dr. MCELROY. Yes, sir. HEW was originally cut back, but upon appeal to the President for the health manpower, that was restored.

Mr. EVINS. Now, Doctor, you say one of the new programs is training science and engineering technologists.

Dr. MCELROY. Yes, sir. That is a very modest program but one we think will grow, Mr. Chairman. It is most important that we train people to fill future needs for high-level technology; not technicians, but technologists. People who have science training but are not Ph. D. researchers. We feel we can make a very outstanding contribution here, no one else is doing it and we see a real future need for highly trained technologists.

Mr. EVINS. This is the age of technology and we ought to have enough technologists to operate the machines.[132]

B2. A New Focus on Pre-Service Teacher Training

Dr. McElroy proposed to put the focus on NSF's teacher education efforts on the pre-service training area, so that, even though some retraining would always be necessary to maintain currency, teachers would be better trained in science in the first place. The committee report did not accept Dr. McElroy's assurances that his plan would be more effective, and once again the appropriation contained a minimum stipulation for institute support. The level was to be $23,630,000—equal to the estimated obligation level of the previous year. The Senate concurred in its appropriation report.

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[131] Ibid., p. 593, 594.
[132] Ibid., p. 632, 633.

This reaction of the appropriation committees may have been predicted on indications that Dr. McElroy was not sympathetic to pre-college education. One such indication occurred in the House authorization hearings, when Mr. Daddario inquired about why funds had been shifted from the pre-college Science Education for Students Program to the Undergraduate Education in Science Program. Dr. Fontaine had originally indicated that the Bureau of the Budget had made the reassignment, then the actual story emerged:

> Mr. Daddario. What influence was there on your thinking by the Bureau of the Budget? My concern is that you went there with a $7 million program divided $3 and $4 million. Now you come to us, having conferred with the Bureau of the Budget, with $2 million in the high schools and $5 million in the undergraduate. The same amounts of money are there, but with considerable adjustment.
>
> Did you decide to put the added emphasis on the undergraduate program on your own, as a result of something that happened to your thinking on education as you walked through the Bureau of the Budget, or did you come to this conclusion for some other reason?
>
> It doesn't seem to me to fit together.
>
> What was the reason for change?
>
> Dr. Fontaine. Mr. Chairman, I think in this particular instance, there is only a very small adjustment.
>
> Mr. Daddario. I understand.
>
> Dr. Fontaine. The problem in education, of course, is that we have had to make not only this small adjustment, which actually doesn't result in a decrease, but also other adjustments within the total to account for a $24.8 million decrease in the overall programs from the current 1970 level.
>
> So, as the budget process goes, in this case it was simply the influence of a new Director, a man who has a very deep appreciation for undergraduate as well as pre-college education. After we had conferred on this, it seemed to us more appropriate to put additional emphasis on the undergraduate students; to bring it to the forefront and identify it in such a way that it would be known nationally, instead of continuing the activity under the special project category.
>
> Mr. Daddario. All right. That is a very sensible reason.
>
> If the Director, analyzing this, felt that changes should be made, and has asserted his leadership in this way for these reasons, the committee is happy to know that. This is precisely what we are searching for. We want to see what changes there are, and why, and see whether or not they deserve support?
>
> Dr. McElroy, do you wish to comment on that?
>
> Dr. McElroy. Yes.
>
> This wasn't really interaction with the Bureau of the Budget. Tom Fontaine and I got together on this, when in a further review of the budget we noted preliminary reports on a successful summer project conducted by undergraduates. He will comment on this later.
>
> It turns out that it is remarkable what undergraduates can do if you give them a little support to get them going on the research they want to do. We supported an experimental student project at California Institute of Technology this past summer, and it appeared to us the time had come to move in this direction in a modest but deliberate way. We asked for the additional million dollars for that purpose.
>
> Mr. Daddario. And you were willing to give a little on the other?
>
> Dr. McElroy. That is right. Despite the squeeze on funds and the general inflationary problems, we felt this undergraduate program was important enough to warrant a positive step in this direction.[133]

B3. Some Questions About the Reasons Behind the Changes

The authorization committee in the House, and that in the Senate, may have sensed a lack of deep, interest in the sort of approach to teacher education (and possibly in high school teacher education itself) that Congress had long favored. The Traineeship awards, started in consequence of the Gilliland recommendations in fiscal year 1964, were to be phased out under urging by the Administration.[134] This, and other adjustments which had occurred in negotiation with the Bureau of the Budget, had produced a significant reduction in the proposed NSF budget for education, as shown in the table below.[135]

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[133] U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research and Development. Hearings, 91st Congress, 2nd session. 1971 National Science Foundation Authorization. Washington, U.S.Govt. Print. Off., 1970. p. 275.

	Request to BOB	Request to Congress
Science education support:		
Student development:		
Science education for students	$3.0	$2.0
Undergraduate education in science	4.0	5.0
Graduate fellowship and traineeships	53.5	31.3
Other fellowships	2.0	2.0
Advanced science education programs	1.1	.9
Subtotal	63.6	41.2
Institutional personnel developemnt:		
Institutes	33.3	20.1
College teacher programs	6.4	5.0
Science faculty fellowships	3.0	3.0
Advanced science education programs	1.0	.8
Subtotal	43.7	28.9
Instructional program development:		
Course content improvement	8.0	6.2
Cooperative college-school program	8.0	5.0
Science curriculum improvement	17.8	9.3
College science improvement	8.0	4.0
Senior foreign scientist fellowships	1.0	.7
Advanced science education program	2.0	1.6
Subtotal	44.8	26.8
Total	152.1	96.9

It was not clear who had made the revisions or exactly why, but the budget request for education was only $96.9 million, which was a $55 million reduction from the level submitted to the BOB and about $23 million below the expected obligations for education in fiscal year 1970. Moreover, the program for pre-college education outlined by Dr. Fontaine and Dr. McElroy appeared unrealistically hopeful to the committee. Mr. Daddario even saw some dangers in the situation. Speaking of the Foundation's program to revise its precollege education programs over the next several years, Dr. Fontaine said:

> We plan, in fiscal year 1971, to begin to move more pointedly into this type of activity. Some of the teacher institutes, for example, will be used to train well prepared teachers to develop and test their own curricular materials under expert scientific and educational supervision. At the end of such a training session the teachers will not only be able to take back to their schools their own good teaching units—with which they are emotionally identified and thoroughly familiar—but be reasonably competent to continue to become course developers within their own schools.
>
> We will also expect to encourage and support colleges and universities in their pre-service teacher education training programs to expose prospective teachers to the development and testing of instructional units.

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[134] Ibid., p. 282.
[135] Ibid., p. 46.

If this approach—the third phase of our long-range plan—works, the capability of schools to improve their own programs will have been increased substantially and their dependency upon outside resources, especially ones not precisely suited to their local needs, correspondingly reduced.

In short, this phase is an attempt to see what can be done to develop in the schools themselves the capacity for improvement. We believe, however, that for a long time it will be necessary for the big steps in curriculum reform to be developed on a national, large-scale basis; we do not immediately foresee any school system building the knowhow to break wholly new ground itself.

A final phase would be the execution of a widespread improvement program instigated and implemented by the schools themselves. Whether that phase will require substantial federal funds, and whether a significant proportion of those funds for the science programs should be part of NSF's budget, are for the immediate future moot questions; however, it is possible that the Foundation will support in Fiscal Year 1971 a number of experimental projects to test the theory.

But even assuming that when the last stage is reached and substantial funds are needed, at least there will be great likelihood that they will be employed to real effect because of our support of the third phase and our experimental efforts in the final phase.

Mr. Daddario. Dr. Fontaine, you touch on the need for schools to develop programs of their own, and with impetus and innovation coming from the schools. You talk about their local needs. You touch on the need to develop "substantially courses and instruction in their schools." You stress how difficult this is.

What are you aiming at?

How do you break this down?

Do you really mean each school to develop programs to satisfy its own needs?[136]

Slightly later:

Dr. Fontaine. The point I was trying to make is that the decrease of $24.8 million does not give you a true picture, a total assessment of the education programs and that in fact we have given very careful attention, even under a very tight budget, and placed particular emphasis in certain areas, as I have indicated.

Mr. Daddario. How do you put this all in balance with taking all these programs together, your $96.9 million figure, the adjustments you have made, your indication to the Committee that you have made every attempt to put this in balance and, finally, with the problems that have arisen in these areas as a result of your original request to the Bureau of the Budget and a reduction in the amount of $152.1 million? The adjustments that need to be made are much stiffer, really, considering what you would like to have done. Where does that leave us?

You are getting $55.2 million dollars less than you had originally programed for yourself, and for which I presume you could have utilized for these purposes. So where does that leave us?

Dr. Fontaine. This is certainly correct. I think if you look at our educational system as a whole there is no question but that additional funds could always be used. But within the Federal establishment, within the Foundation, decisions of priority have to be made, and within those overall priority decisions it was the responsibility of Education, in consultation with the Director, to make the adjustments as we have indicated here.

We believe that the programs are in balance, that it is absolutely essential that we move forward in strengthening the pre-service education, that we begin a more effective and concentrated program in the technical education area, and other technical areas.[137]

And a little later:

Dr. McElroy. * * * .

Up to now we have put roughly $460 million into the summer institutes for high school teachers and we think we have reached the maximum benefit from this approach. We think it is time to turn around and reexamine our whole approach. We think we have several good approaches and know how to develop them. We are doing modest experiments this coming year to make sure that we know what we

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[136] Ibid., p. 286.
[137] Ibid., p. 290.

> are doing, and to see the results. Next year we hope to return to the Committee with significant increases in the other programs which will then take up and, I think answer, the question you are raising.
>
> I think we need to get in and get the teachers and the principals of their schools involved in these programs. Until recently it has been the teacher on his own, going to the summer institutes, with no real input back at his institution except possibly in his own classroom. We need to get the curriculums reformed throughout the system internally, so teachers identified by the principals will come back from training and become the leaders for curriculum reform in their own systems and be sensitive to problems.
>
> We are not in a position in this budget to do that fully. But we hope to come back with this broad program and while it will come out at a higher level dollar-wise, it will be much more effective, we think.
>
> Mr. DADDARIO. Dr. McElroy, I have no argument about the need to adjust programing from time to time. And I do think we do not move with as much dispatch as we should, we are not as flexible as we ought to be.
>
> Yet, I am somewhat concerned about large cutbacks all at once, with the idea that sometime in the future we are going to get some of this money back, and so we all ought to be happy about that. Because we are cutting back in many of these areas, I have tremendous concern.
>
> Recognizing what you say, I wonder how far back we can go, and how much we can depend on promises in the future for needs of today.
>
> Dr. McELROY. The major cutback is in summer institutes for high school teachers. As Dr. Fontaine indicated 40 percent of our high school teachers have now participated in one or more of these.
>
> Unfortunately we don't have, but hope to know by the end of the year, how much further we can really go in reaching the football coach who is assigned to teach biology at the high school level.
>
> Mr. DADDARIO. Don't knock the football coaches.[138]

It would appear that whether or not the impetus for the budget reductions in education came from the Bureau of the Budget, Dr. McElroy was probably an unlikely candidate to champion pre-college institutes.

B4. An Emerging Project Emphasis

The NSF program accomplishments of Fiscal Year 1971 in pre-college education indicated an attempt to follow the sorts of concepts laid down by Dr. McElroy wherever possible. The summer institutes still focused on curricula and on teachers' gaining leadership skills by attending sequential series of institutes. Approximately half of the institutes used NSF developed materials to some degree. But attempts were made at self-development as outlined by Dr. McElroy:

> An innovation introduced in the Summer Institute program is exemplified by five projects in which groups of participants from a particular school attend the institute to develop and adapt course material for use in their own classes when they return to school. One such project enrolled 20 participants in teams of two to five teachers from a single school. Admission to the institutes was based on the merits of proposals from the teacher groups for the summer's work, with the period of participation varying from 6 to 10 weeks. The staff of the Education Research Center at MIT provided support, guidance, and facilities for the participants in the institute.[139]

And other attempts at innovation appeared to be less discipline-oriented than before, and were structured to train pre-college teachers for specific leadership or supervisory roles:

> In the appropriation act for fiscal year 1971, a large proportion of funds for in-service education of teachers was earmarked for support of summer institutes

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[138] Ibid., p. 291, 292.

[139] National Science Foundation. Twenty-First Annual Report for the fiscal year Ended June 30, 1971. Washington, U.S. Govt. Print. Off., 1972. p. 77.

> for secondary school teachers. As a consequence of this, Academic Year Institutes (AYI) had to be limited to projects providing leadership and supervisory training. Such projects could have a "national orientation"—drawing participants for leadership training from the country as a whole—or a "regional orientation" focused on a service area around the host institution. Of those in the first category, the AYI at the University of Wisconsin is a good example. Ten science teachers and 10 mathematics teachers who have strong academic and teaching records, hold master's degrees in science or mathematics, and are interested in supervisory training are selected nationally for a full calendar year of advanced work at the University of Wisconsin. During this time, each participant spends a semester of supervisory internship in a selected school system, which may be in one of the larger city systems in Wisconsin or be in association with one of the Cooperative Educational Service Agency (CESA) districts in that State. The other semester and the related summer are spent in academic work relevant to supervision, but concentrating on the participant's specific discipline. The cooperating school systems contribute substantially to the project.
>
> The AYI at the University of North Carolina is representative of the second or regionally oriented type. This project involves an interrelated mix of three categories of participants from North Carolina: experienced teacher, intern teachers, and undergraduates who are preparing to become teachers.
>
> Twelve intern teachers, after spending a summer and a semester in residence, will be formed into six teams, each of which will replace an experienced teacher who will then return to the campus for a full semester of study. During the preceding summer, the six experienced teachers will have been on campus for one of the summer sessions, interacting with the intern teachers who will replace them. During the following summer, the experienced teachers will again be in residence on campus for further work in the program. Concurrent with this activity, and beginning in their sophomore year, six undergraduates preparing for teaching careers will be involved in progressively more responsible positions as paraprofessionals, working with the interns and the experienced teachers in the cooperating schools. As a consequence of this experience, their awareness of the practicalities of teaching as a career and their dedication to the profession should be enhanced.[140]

Though these programs may have constituted a more direct and efficient approach to certain problems in pre-college education, they also tended to involve NSF more intimately in the affairs of certain schools and in matters affecting how schools are operated generally.

Finally, it should be noted that in fiscal year 1973 the Foundation revised its program names and budget format for a third time, with the result that fiscal year 1971 and fiscal year 1972 obligations were only reported in the fiscal year 1973 format. Since new the labels in the budget did not correspond with former titles the changes appeared confusing.

Comparing with the budget breakdown in Appendix A for fiscal year 1971, the transformation was simple even though the advantages in the new labels seems doubtful. *Summer Institutes* were renamed *Secondary School Teacher Projects*, so far as pre-college education is concerned. Other program names in pre-college activities remained much the same and stood for much the same activities. However, the names seemed to emphasize the concepts of project orientation: i.e. undertakings having a definite lifetime. This has been purported to reflect the policies of the Office of Management and Budget, which was reported not to favor continuing aid to education but apparently would allow Federal help to achieve specific goals.

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[140] Ibid., p. 76.

C. FISCAL YEAR 1972—NSF REPROGRAMS PRE-COLLEGE EDUCATION

As the House Subcommittee of the Committee on Appropriations opened hearings on the Fiscal Year 1972 budget request, the members showed concern about technology transfer and utilization: how to get research findings into use. This, of course, underlined the high priority of the new RANN program at NSF. On the other hand, the members were uncomfortable about continuing drop-offs in student applications for admission to colleges and universities to study science. Another concern was the termination of support for basic research programs by the Department of Defense in consequence of the *Mansfield Amendment*. This appeared to be posing a much greater support problem for NSF.

In summary, the focus of attention was on problems in the research community: a lack of demand for Ph.D. scientists; a reduction of Federal interest in research, which might have been partly responsible for the apparent oversupply of scientists and engineers; and the need to apply research results and thereby create a new demand for research and for trained scientists. The subcommittee members recalled a seemingly prophetic report by Dr. Allan Cartter in 1966, in which he had predicted an oversupply of scientists if Ph.D. production rates of 1966 were continued. Serious attention was therefore not directed toward pre-college education in fiscal year 1972. If anything, the mood might have been to de-emphasize education programs, just as the termination of the graduate traineeship programs seemed to indicate. However, the redirection of funds from, and the re-programming of, the summer institutes sparked considerable interest in the subcommittee.

C1. A Major Reprogramming Begins

Dr. McElroy proposed a number of changes in the education program structures and objectives, some of which affected precollege education efforts rather extensively. Dr. McElroy began his presentation of the education planning with a statement of the philosophy which guided this re-programming:

> Dr. McElroy. Mr. Chairman, I know that the members of this committee are aware of certain changes in our science education program. Within the $77.3 million being requested for these programs for fiscal year 1972 we have made these changes for well considered reasons. They will, we believe, result in more focused, more efficient use of our resources. In formulating our science education program, we have applied four criteria to guide our priority selection in the development of the 1972 program.
>
> The first and most important criterion is societal need. In the last analysis we depend on staff judgment as approved by the National Science Board in making these determinations, but judgment is aided by many sorts of information. Studies carried out by staff members who administer the various education programs and also studies carried out by others in the Foundation, such as those concerned with manpower analysis and policy studies, make important contributions. Independent external studies, such as those made by the Carnegie Commission on Higher Education, the Presidential Commission on Higher Education, and the National Academy are other important sources. Among these we have noted in particular the most recent recommendations from the Carnegie Commission entitled "Less Time, More Options." Among the options for which we have provided in our budget are (1) new introductory courses in science organized around societal problems rather than by the traditional disciplinary approach, (2) improved technological training to support the scientific enterprise in both research and applications of research, and (3) new graduate degree programs in the practice of science, such as science teaching. These budgetary provisions are components of both curricula development and teacher development which I will discuss later in more detail.

> The second criterion is effectiveness. Both the amount of change and the number of students affected by the change are important. Curriculum development, broadly defined, and teacher development generally benefit more students than economically feasible student programs.
>
> A third criterion for a high priority program is that it should be possible to accomplish the objectives of the program within a reasonable period of time, and within the budget which is likely to be available for these programs. The number of programs in which indefinite funding is required should be kept to a minimum. For instance, a good curriculum project may last 5 to 10 years, but it still has a beginning and a terminal date.
>
> A fourth consideration is successful programs must be maintained at an effective and efficient size. When budgets are tight, there comes a time when it is necessary to drop some useful programs to zero rather than to reduce all programs uniformly.
>
> When these four criteria are applied within the education program areas, the program priority in order is instructional program development, instructional personnel development and student development.[141]

Speaking of the various programs, Dr. McElroy made the following points. Regarding institutes at the pre-college level, his justification material stated that:

> Currently, emphasis is being placed on areas of special importance nationally including:
>
> social sciences,
> scientific areas relevant to environmental problems,
> interdisciplinary areas,
> traditional disciplines of particular importance to the national economy,
> emphasis on relevant teaching programs and curricula, (increasingly, teacher institutes, especially for high school teachers, are being related explicitly to the efforts of school systems to adopt new teaching programs which usually entail teacher retraining).
>
> In addition, these programs have been expanded in scope, if not in size, to include some provision for:
>
> training competent teachers to become curriculum development and/or teacher retraining specialists in their own schools, and
> providing supervisory and administrative personnel with real understanding of new curricula so that they may judge their suitability for adoption.
>
> In substance, the programs are being modified extensively to develop leadership personnel in the hope that, in time, there will be less need for Federal funds and professional assistance from outside the schools themselves.[142]

The justification material continued with a description of the former objectives and methods of the summer, academic year, and in-service institutes (i.e. subject matter instruction with an emphasis on the use of new curricula), and then went on to state:

> Academic Year Institutes were reduced in fiscal year 1971 to about one-quarter of the fiscal year 1970 level. In fiscal year 1972, the Foundation plans to continue to support them at about the same level as in fiscal year 1971 and will accomplish the overall reduction of its support of institutes through a decrease in awards for Summer Institutes.
>
> Two new approaches, begun at an experimental level in fiscal year 1971, will be increased in fiscal year 1972. One of these, entitled the Comprehensive Teacher Education Program, is aimed at supporting an integrated and correlated set of teacher education activities, both pre-service and in-service, at colleges that have demonstrated excellence and continuing interest in conducting teacher retraining projects. Instead of supporting several independent institutes at a participating institution, a package Science Education grant to an institution will provide for a planned and specified set of activities designed to improve the teacher training activities in all aspects. Five experimental projects of this kind are being developed in fiscal year 1971. These will be continued in fiscal year 1972 and three additional projects will be started.

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[141] U.S. Congress. House. Subcommittee of the Committee on Appropriations. HUD-Space-Science Appropriations for 1972. Hearings, 92nd Congress, 1st, 1st session, Washington, U.S. Govt. Print. Off. 1971. p. 85.

[142] Ibid., p. 341.

The second of the new approaches is a statewide or regional systems approach aimed at the improvement of teacher training and curricula in the schools. Each project will be a cooperative venture involving the active participation of state, local, private and Federal organizations which are now engaged more or less independently in meeting the need for science and mathematics improvement in the elementary and secondary schools. Activities will include coordinate in-service and pre-service teacher education, curriculum development or adaptation as needed, the development of local resource personnel for consultation and continuing education, and the development of science education centers in the universities. One such project is being developed in fiscal year 1971 and NSF plans to add another in fiscal year 1972.

Emphasis will be further increased in the summer program on institutes with interdisciplinary approaches including such subjects as oceanography and marine sciences, ecology, behavioral science, social science and the problems of society related to science and technology.

Finally, many institute projects will be directly related to the new curricula and course material interests of school systems. Teacher participation in these projects will be contingent on the endorsement of the teacher's institution to insure that there will be maximum opportunity for introducing improved science instruction programs in the school.[143]

Thus academic year institutes had been reduced, summer institutes were about to be reduced, and programs were being re-structured to deal primarily with school systems—both in the selection of topics and in the selection of students. In addition, Foundation support of its education programs was to be reduced by $23.3 million to a level of $77.3 million, in spite of a requested increase in the total NSF budget of $109 million to a new high level of $622 million. Of that $233 million reduction, $6.8 million would be taken from pre-college programs, which were scheduled to receive a total of about $40.0 million in fiscal year 1971. (The remainder of the $23.3 million reduction would be accomplished by a termination or reduction of graduate and faculty fellowships and traineeships.)

The subcommittee demanded further justification for these changes. *Dr. McElroy maintained that the former education programs, like the institutional programs of Science Development and University Science Development, had reached their objectives.* Congressman Giaimo demanded specific information:

Mr. GIAIMO. Can you justify the reduction in science education support?

Dr. MCELROY. It is almost the same argument I used for the institutional support program.

The big reduction, of course, is in the traineeship program for the direct support of students. The postdoctoral program and the senior foreign scientist program have been reduced to zero.

Mr. GIAIMO. It bothers me that you may be changing direction from the one that has served us well in the development of our science capabilities.

In your justification you state, "emphasis will be placed on courses of a multidisciplinary nature centered on problem themes, while support for the improvement of conventional science courses will be deemphasized."

Dr. MCELROY. Those are primarily at the junior high-high school level. It is quite clear that the old post-sputnik aim was to develop good math and physics programs in the high schools. That has had an impact on the total United States and a lot of foreign countries.

There is now a great concern among both science majors and nonscience majors to get a broad look across the board at some of these major problems.

Mr. GIAIMO. Do you mean major problems like the social sciences?

Dr. MCELROY. And the pollution problems we are faced with. The problems of the urban systems and so forth, which require interdisciplinary approaches and not discipline by discipline.

A lot of emphasis has been created in the high schools and among the people there to develop curricula for students to look at these problems, using all the sciences, to bring action to bear.

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[143] Ibid., p. 342.

Mr. Giaimo. Are we now going to have a liberal arts approach to science education?

Dr. McElroy. I don't think so. After all, I guess, a good 85 percent of the students who go through high school science are not going to be scientists.

Mr. Giaimo. They are going to be trained in scientific disciplines.

Dr. McElroy. Yes, but what we are trying to do is to let them learn the principles of science and see how it might be applied to society's problems. We will still be concerned with the quality of the science mission; there is no question about it.

We think now that we have developed the curricula for the high school using university people, that this type of effort is going to continue. As a matter of fact, it is a good commercial venture now, and industry has done everything possible to emulate this program. We think there are adequate stimuli now that will keep efforts at a high quality level and we will keep an eye on it. If we see quality going down in good science instruction, certainly we will step in and increase emphasis on curriculum development.

Mr. Giaimo. Your job is to stimulate these universities and once this is accomplished, they must carry on alone. Am I wrong?

Dr. McElroy. Not completely. We can't completely underwrite the total efforts of the scientists in the universities. We are in the business of supporting their good research

Mr. Giaimo. Through your research programs.

Dr. McElroy. Yes, sir.

Mr. Giaimo. But not directly through your student development program. Is that correct?

Dr. McElroy. Not directly; that is correct.

Mr. Clawson. What is the actual mechanism for channeling the funds in the assistance program?

Dr. Humphreys.[144] The mechanism is curriculum development, to have curriculum groups formed into teams of secondary and primary teachers and scientists at the college level. These groups develop new curricula, as a team, good science is put in and the problems of teaching at the secondary level, or lower levels, are kept well in mind.

Mr. Clawson. Do these high school and junior high teachers actually participate in this exchange?

Dr. Humphreys. They participate in the exchange and then as the curriculum is being developed, it is constantly tried out in various institutions. When it has reached a more or less finished state, we then support, with our institutes, the training of additional teachers to handle the new curriculums.

Mr. Clawson. The high schools and the junior high schools don't actually receive the funds, do they?

Dr. Humphreys. The high schools and the junior high schools do not actually receive the funds. Our institute funds are channeled through colleges and universities which conduct the institutes and select the teachers for participation in the institutes.

Mr. Giaimo. What level of funding is presently projected for science education support for the next 5 years?

Dr. Humphreys. We are doing some rethinking and reprograming at the present time. We certainly anticipate coming back here next year with an increased request for science education as a part of the total NSF budget.

Dr. McElroy. One point on that, which I should have mentioned earlier, is an experiment that looks like it is going to work. We started recently an experiment in the total State of Delaware, to attempt to bring good educational efforts to the junior high level in science throughout the whole State.

Now, if this works as a system—and we have some very innovative things there and some innovative people working on this—we think this program should be expanded throughout the country. This will mean, of course, that the Office of Education, as well as NSF, will have to get heavily involved in these demonstrations. We are looking at the possibility of doing two or three similar projects in areas or States in 1972 and 1973. We feel that this is a much more effective way of bringing impact to a total State. Don't do it piecemeal; bring the whole thing up to eye level all at once. We think we can do this with a modest amount of money. In this case, we have gotten contributions from the Du Pont Co., from the local educational groups and from the universities and the high school and junior high school districts.

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[144] Dr. Humphreys was NSF Assistant Director for Education.

If that experiment works and we can get approval from OMB for the funding, that could go up quite rapidly in the next few years.

Mr. Giaimo. I will say it again, Doctor, I wish you would give us a concise statement that Congress can understand as to why we are witnessing a decrease in support of scientific education. There is a great deal of interest in this area. If we are going to make a decision on this, I think we should have the information. I am still up in the air on your reasons for the decrease in support.

Dr. McElroy. Let me try to explain it again. In terms of keeping innovative curriculum reform going, we have not deemphasized that. In terms of the development of the personnel to carry out those curricula, we are continuing the summer institutes——

Mr. Giaimo. The traineeship program is being phased out as are the science faculty fellowships.

Dr. McElroy. Mr. Giaimo, as you know, since you introduced a bill, there is concern in this country, today, about unemployment among scientists and I guess, in part, this is a response to that problem.

Mr. Giaimo. Let's talk about that. I don't think it is the function of the National Science Foundation to solve the problems of the economy. Your function is to make sure that we have technological capabilities and trained scientists in the future. I know we have economic problems and the unemployed scientists and engineers have to find jobs, but I also feel this country has got to develop good multidisciplinary research. We can't afford to fall short in this area.

Dr. McElroy. I agree 100 percent, and I guess, in part, we are responding to what I was criticized for, not anticipating an over-production of Ph. D.'s.

Mr. Talcott. We are going to have a lot of unemployment among teachers and other social science groups if we continue to put emphasis on those areas just because they are relevant to the social and environmental problems.

Dr. McElroy. I think those are some of the toughest problems. I don't think they are easy.

Mr. Talcott. It looks to me like you are trying to get away from the disciplinary courses.

Dr. McElroy. I hope we didn't give that impression. Our biggest increase is for good disciplinary research, and we are all for that. This is what I was saying. This is where we want to put our big effort. Maybe we didn't put in in the right places, in some people's judgment, but in our opinion, with the judgment we have, we need to keep our scientific enterprise alive and that is where we are putting our money.[146]

The subcommittee then proceded to question Dr. McElroy in detail about each of the reductions he planned.

C2. Congress Protects the Institutes

The appropriation bill, H.R. 9382, 92nd Congress, 1st session, again included a stipulation that $23.3 million be available for tuition, grants, and allowances in connection with a program of summer institutes for secondary school science and mathematics teachers. The Senate Committee on Appropriations submitted a report (S. Rept. No. 92-264) stating that not less than $28.8 million should be available for "Institutional Support for Science" and not less than $99.3 million for the programs in "Science Education Support." In conference, both of the Senate stipulations were maintained, and the stipulation for summer institutes was raised to $28.8 million.

The total appropriation provided for fiscal year 1972 was $619.0 million, the large amount reflecting the need for the Foundation to assume support of research programs dropped by other agencies.

Before the fiscal year 1972 was over, both Dr. McElroy and Dr. Humphreys, Assistant Director for Education, resigned to accept other attractive opportunities. Dr. McElroy was replaced as Director by Dr. H. Guyford Stever in February, 1972 and Dr. Keith Kelson became Acting Assistant Director for Education. The new directions, however, would largely remain, but only after study by the new Director. These new directions will be discussed further in the description of activity in fiscal year 1973.

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[146] Ibid., p. 350-352.

C3. OMB Impounds Education Funds

It should be noted that $16 million of the $99 million provided for education in the fiscal year 1972 appropriation was impounded by OMB, leaving an effective appropriation of $83.3 million for education.

D. FISCAL YEAR 1973—NEW OBJECTIVES EMERGE

Appropriation hearings began in the House for the proposed fiscal year 1973 budget for NSF only 27 days after Dr. Stever had been sworn in as Director. Thus, the comparatively small budget proposed for education programs could not be attributed to him.

The impoundment of education funds by the Office of Management and Budget for fiscal year 1972 created a considerable problem for the House and Senate committees, in that they saw no way to override Administration decisions to reduce the NSF education budget. They were also critical of the nature of the new NSF programs in terms of their objectives and the reductions in support.

In addition, the changes in program title instituted for fiscal year 1973 caused confusion, since it was very hard to tell where a former activity might appear in the budget. Some former programs had been divided, and the parts incorporated with other activities in the new format.

This created some definite concern in the House Committee on Appropriations. But the major concern, aside from impoundment, was the apparent reallocation of money to the RANN program. The committee report makes this point very clearly:

> The Committee has always given strong support to the National Science Board in its efforts to engender greater scientific capability in our Nation. There is a growing concern, however, that the Foundation may be failing in the original mission it was created to accomplish.
>
> In the period of time preceding World War II, other parts of the world made substantial contributions to basic research. This served as a reservoir of knowledge for the use of any country in the development of applied research. When the basic research capability in European countries was destroyed by the war, the Foundation was created with the purpose of helping to fill the void. This increase in capabilities was clearly in our national interest.
>
> Immediately after World War II there was a parallel influx of capable, highly trained scientists and engineers from abroad. These helped to meet an existing national deficit for such personnel. Many outstanding teachers and scientists are part of the continuing technological advance of our Nation today.
>
> A new emphasis has developed in National Science Foundation programs in recent years. This appears to put more emphasis on techniques and methodology, and less emphasis on fundamentals and substance. The often expressed concern of knowledgeable individuals that the Foundation may assume the role of directing instead of supporting research in our Nation appears to be evolving in the RANN program, and in other new approaches that are proposed in the budget.
>
> The Committee is apprehensive that this new support and promotion of short term goals is indirectly cutting into support of established and basic programs, such as institutional and graduate student support. Valuable and proven programs to upgrade teaching and improve science departments have been deemphasized in favor of new applied research objectives. This is happening at a time when other departments and agencies are also moving toward applied research with the hope that the National Science Foundation will pick up part of the slack in the more fundamental areas.

> There are reports that the decline in institutional and graduate student support is starting a reverse brain drain from the United States. The National Science Board is admonished to monitor this trend carefully. While some of the short term policies of the budget may be appealing in terms of immediate payout, the concern of the Committee and the Congress is that the critical loss of capability in other programs will appear in strange, often untraceable ways some five, ten or twenty years later.[148]

It was several years before the criticism, from the scientific community as well as from Congress, about the threat of applied research would ameliorate. In the meantime, the NSF Education Directorate would continue to appear to be in a constant state of flux and under continuing scrutiny from the NSF management.

D1. Management by Objectives for NSF's Pre-College Programs

There contined to be unsubstantiated reports that the Office of Management and Budget was either determined to shift the science education responsibility to HEW, or that OMB was opposed to any program of Federal support to education on a continuing basis. According to these reports, it might be acceptable to perform some specific project, such as to develop a specific curriculum, or to help a region to upgrade science education in its local schools. On the other hand, it was supposedly not acceptable, according to these rumors, to support institutes or to support traineeships or to maintain programs similar to institutional grants that constituted continuing programs.

According to this scenario, NSF education had to be put on an objective-oriented project-by-project basis. And whether the reports had substance or not, the actions of NSF would seem to have been in accord with such administrative concepts. The programs continued to perform many of the continuing functions mandated by the Congress: there were, in essence, still summer institutes and the CCSS activity still survived in concept. But the names of programs indicated very different activities: *Experimental Models and Demonstrations, School Systems and Colleges, Problem Assessment and Experimental Projects,* and so forth.

It was hard to determine how much money might be supporting any one of the older activities, because the old activities might appear under any or all of several new titles. Members of the various committees dealing with NSF complained that they could neither understand the content of the new programs nor understand why, after all these years, the programs to overcome the continuing need for teacher re-education and curriculum revision were being scrapped.

NSF claimed that teachers had been re-educated and that the big demand had come to be for the adapation of existing curricula to the needs of each school system. This was, so NSF claimed, the barrier to the use of new curricula, rather than the inadequacies of teacher training. NSF also claimed that by dealing with a few key personnel, who would instruct other teachers and provide for implementation of new curricula—or who would even design new curricula which would then presumably be optimally suited to their own schools—the problems of pre-college education could be overcome most efficiently.

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[148] U.S. Congress. House. Committee on Appropriations. Department of Housing and Urban Development, Space Science, Veterans, and Certain Other Independent Agencies Appropriation Bill, 1973. Report [to accompany H.R. 15093] Washington, U.S. Govt. Print. Off. 1972. H. Rept. 92-1071. p. 17.

This new degree of efficiency was said to compensate for, or perhaps account for, the reduction in budget for pre-college education. The comments from certain members of the appropriation and authorization committees indicated a preference for the direct instruction of teachers in institutes as opposed to their indirect instruction at the discretion and under the direction of school administrators and key personnel. The committees apparently did not really favor the NSF arguments that (1) summer institutes were not reaching 50% of the teachers and (2) that summer institutes had become something of a subsidized vacation for other teachers who attended every summer.

Members of the appropriations committees frequently reminded NSF officials in hearings that occurred in fiscal years 1971, 1972 and 1973 that it was *they* who had insisted that NSF make something out of the early experimental institutes efforts, and that it was *they* who had favored the program over the years and provided strong support; and that *NSF had said* on numerous occasions in hearings that the institutes were among their most successful efforts.

Discussions relating to certain other programs were in similar vein, and mutual confidence seemed to suffer. Presumably as a result, Congress instituted line-item budgets and retained a stipulation of minimal expenditures for institutes.

The NSF annual report for fiscal year 1973 indicated some important further changes in the direction of the education programs:

> In order to discharge responsibilities in fiscal year 1973, *the Foundation very sharply focused its efforts toward the resolution of a selected set of problem areas* of concern to the academic community and to the Nation as a whole. *These problems include the need to:*
>
> *emphasize qualitative rather than quantitative aspects of scientific training* for career scientists;
>
> *improve the cost effectiveness of science education through the development and implementation of improved educational materials and technologies, instructional strategies, and methodologies;*
>
> assure the Nation of appropriate variety, flexibility, and numbers of scientific and technical manpower.
>
> provide improved science education for a broader range of students including the nonscientist;
>
> provide more adequate opportunities for continuing education outside the formal educational system for the Nation's technologically based society; and
>
> improve the Foundation's coverage of information on the supply and utilization of the Nation's science resources.
>
> In seeking resolution of these problems *the Foundation has, more than at any previous time, sought to provide assistance in a way that would enable schools, colleges, and universities to develop their own capability for self-renewal in science education.* This philosophy, while implicit in the Foundation's past Science Education Improvement support activities, was made explicit in each of the fiscal year 1973 programmatic thrusts and has been carried forward into plans for fiscal year 1974.
>
> As an example of the increase in emphasis on this philosophy, the Foundation's support of activities to provide supplementary training for secondary school teachers of science and mathematics was in years past focused on increasing the subject-matter competence of the individual teacher. Gradually, *emphasis has shifted from focusing solely on the teacher to greater concern for improvement within the teacher's school or school system.* This shift manifested itself within the several program activities for in-service teacher training where, by the late 1960's, *applicants for participation in summer institutes were required to document in their applications the manner in which attendance at an institute would have an impact upon the instructional program of their school or school system.* Similarly, the gowth of the

> Cooperative College-School Science Program during this period directly implemented this shift of focus. By bringing to a local school or school system the resources of a local college or university and applying these resources in a jointly planned effort to solve problems associated with upgrading science instruction at the pre-college level, instructional reform was effected. Activities at both the undergraduate and graduate levels of education also emphasized the development capacity to implement needed educational reforms.[146a] [Emphasis added.]

The fiscal year 1973 program format for education is indicated in the budget in Appendix A. Though the NSF Annual Report for fiscal year 1973[147] provides an extensive description of the program, the text is sometimes confusing in its attempt to indicate the full breadth and latitutde available to each sub-program. Accordingly, the description given in the report of the House Committee on Science and Astronautics (H. Report No. 92-977) to accompany the fiscal year 1973 appropriation authorization bill for NSF is provided here in the interest of clarity and brevity:

> The purpose of the Science Education Improvement program is to help improve the effectiveness of science education at all academic levels. It is focused on major science education problems of concern to academic institutions across the country and to the Nation as a whole.
>
> The emphasis of the NSF Science Education Improvement program is on constructive and innovative change in the methods and resources applied to the teaching and learning of science and engineering in U.S. educational institutions, with further emphasis on the practical implementation of programs and procedures developed previously.
>
> Some science education program elements, such as source and curriculum improvement programs, teacher training programs, and the talented student program have been broadened so that they can have a maximum beneficial impact on selected science education problems within an appropriate time frame. Science Education Improvement projects being supported by NSF facilitate reform in science education, provide education in scientific subjects for a wider variety of students, provide education that qualifies students for a wider variety of career choices, and do so via mechanisms that help stem the rising costs of education.
>
> SCIENCE EDUCATION RESEARCH, DEVELOPMENT, AND DEMONSTRATION
>
> The objective of the Science Education Research, Development and Demonstration program is to improve science instruction through research and through a variety of innovative models and demonstration projects that provide science teachers and administrators with working examples of new materials, techniques of instruction, and mechanisms required for their introduction into the educational system.
>
> The traditional modes of transmitting knowledge—specifically, textbook-based instruction delivered in person by an individual teacher at a fixed time and place—no longer meet the diverse needs of modern science education and the students to whom it is directed. To help correct this situation, the NSF is emphasizing projects that: (1) develop instructional modules adapted to modern communications technology, (2) provide opportunities for instruction and educational experience outside conventional school and university settings, and (3) establish

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[146a] National Science Foundation Annual Report for the Fiscal Year Ending June 30, 1973. U.S. Govt. Print. Off., Washington, D.C. [1974] p. 83 ff.

[147] National Science Foundation Annual Report for the fiscal year Ending June 30, 1973. U.S. Govt. Print. Off., Washington, D.C. [1974] p. 83 ff.

mechanisms for certification of competence derived from other than purely traditional course requirements.

NSF has grouped its science education efforts that are designed to meet the objectives of the Science Research Development and Demonstration program under two elements which are discussed in the sections which follow. These are Development of Alternative Instructional Methods and Materials, and Experimental models and Demonstration Projects.

Development of Alternative Instructional Methods and Materials

The Objective of this program element is to develop appropriate and effective science course materials and methods of instruction and learning for various educational levels. It is subdivided into three major program efforts which are discussed below.

Elementary and secondary science instructional materials.—This effort provides support for projects concerned with the development of science course content, curriculum, and instructional materials required to meet the changing science education needs of elementary and secondary school systems.

Under this program NSF also provides for development of teaching guides and other materials addressed to teachers, as well as to the organizational and administrative structures of schools as they apply to science education. These materials are developed under grants to colleges, universities, other research organizations and professional socicities. Development work involves the collaboration of scientists, science educators, and appropriate school personnel and technical experts.

Undergraduate instructional materials.—These projects are aimed at improving curricula and teaching materials for both those students for whom science is a career choice and for those who do not expect to use science directly.

The substance of science—its body of facts, its theories, and its concepts—continues to grow and change at a rapid rate. So do the needs, both career and non-vocational, of students. The job of translating new understandings in and of science into a form suitable for student use presents a continuing challenge. Likewise, ideas on how best to teach science are changing radically and demand examination, especially in the light of recent advances and accumulated experience in instructional technology and changing student attitudes.

One of the most promising ways of overcoming the reluctance of some faculty members to experiment with new instructional modes is to introduce such schemes of instruction in pre-packaged, flexible modular units employing relatively simple technical devices.

Graduate and continuing education development.—The principal objective of this effort is to foster planning, development, and implementation of experimental instructional approaches to graduate science education.

In addition, a directed effort will be made to improve the proficiency of graduate students serving as teaching assistants. Graduate Teaching Assistants rarely are adequately trained to handle the instructional responsibilities thrust upon them, according to findings of several recent studies. The primary objective of these projects is to show how skills in guiding student learning, handling discussions, and curriculum planning can be incorporated into the teaching assistant system to benefit both the undergraduate student and the teaching assistant.

Experimental Models and Demonstrations

New educational materials and new models of instruction move into general classroom practice only if prospective users have an opportunity to see them in action, and are provided with such evaluations of their effectiveness and estimates of cost as will enable them to judge for themselves the benefits to be derived. To provide such working demonstrations, and to promote widespread knowledge and understanding of them, NSF provides support for experimental models and demonstration projects in the following areas:

Experimental scientific training and course development projects.—These projects include the following types of activities: Supervisor Projects—These include short courses on new curriculum for principals, directors of education, and other school, administrators. Pre-College Resource Personnel Projects—These projects include short courses of 3 to 4 weeks duration, some with follow-up in the academic year which provide leadership training for implementing specific curricular materials in the schools.

Experimental models for course material development.—Under this program, NSF provides for the assembly and distribution of a continuously updated catalog of new materials and innovations in teaching, and for the collection and distribution of such materials to science education learning resources centers now being established at a number of colleges and universities. Comprehensive In-Service Teacher Education Projects—This program provides support for interrelated teacher education activities that offer opportunities for fulltime and part-time study by in-service teachers during the academic year and/or summer.

Pre-service teacher education projects.—These pre-service education projects provide intensive training for the prospective teacher exposing him to new courses, informal training, seminars, and direct experience.

Experimental demonstration projects.—These projects provide support for a broad range of new approaches designed to improve the effectiveness of science education both on a systemwide or regional basis and on an individual institution basis. These approaches include such projects as the following:

State and urban school system projects.—Under this program, NSF provides support for development and coordination of experimental projects designed to foster improvements in science education on a State, regional or other systemwide basis.

Underground student-originated projects.—Students engage in full-time research, usually in the summer, on projects dealing with problems related to the physical, biological, and/or social environment. Each works in an interdisciplinary group under the leadership of a Student Project Director with consultation provided by a Project advisor, a faculty member chosen by the students.

Student-Originated Projects provide high motivation and a reliable test of the students' maturity, problem-solving ability, and sense of direction. By demonstrating the potential of students for solving problems, these activities encourage the development of science education programs that place more responsibility on the student. From a management point of view, these activities can have high impact at low cost.

Technician/technologist education projects.—These projects provide support for activities designed to assist in the expansion and improvement of post-secondary technician and technologist education programs in the United States.

Technician/Technologist Education Projects are designed to increase the number of career options available to persons interested in post-secondary education. They are of special benefit to individuals who are strongly oriented toward practical activities and want to acquire skills with immediate and tangible applications. In addition they provide much needed intermediate level training for technical personnel serving in the vital area between the scientist or engineer and the production worker.

Other experimental projects.—NSF is supporting other experimental projects designed to encourage institutional and individual initiatives in improving science education. These initiatives include awards granted to those institutions, organizations and individuals, in all regions of the Nation that are most successful in effecting improvements in science education.

INSTRUCTIONAL IMPROVEMENT IMPLEMENTATION

There are two acute needs that must be met in promoting the implementation of instructional improvement in the Nation's academic institutions. These are: (1) development within the schools and colleges of an adequately trained corps of teachers to install and carry out the needed improvements, and (2) provision of a part of the funds required to insure that selected institutions have the necessary resources to effect the improvements and that once implemented the new programs have an optimum chance of success. The major components of the Instructional Improvement Implementation Program are discussed in detail in the following sections.

In addition to the sum authorized for fiscal year 1973, it is expected that $5,200,000 of fiscal year 1972 funds will be obligated during fiscal year 1973 for Instructional Improvement Implementation.

Training Educational Personnel for Implementation

The projects supported under this program element are designed to improve the capability of science faculty to implement new science education programs, such as new and improved science curricula and teaching modes. Making instructional personnel more effective is a key requirement in the NSF effort to stimulate constructive changes throughout the U.S. science education system. Teachers and educational administrators must be prepared and motivated before educational improvements can be implemented.

NSF support under this program element is concerned chiefly with the science instructors' problems in adopting the new science curriculum and course materials that are being developed under the Science Education Research, Development and Demonstration subactivity and in adapting them to specific teaching requirements.

This program is subdivided into three major efforts which are described in the following paragraphs.

Secondary school teacher projects.—These projects provide support for in-service teacher education at the secondary school level. They are designed to increase the teacher's effectiveness in the classroom and thus his student's performance. These projects are administered during the summer or outside school hours during the academic year, or both. Some of them develop leadership potential; others are concerned with special in-service training requirements in specific areas. The latter involve education training in environmental and societal problems, in-depth studies of new curricula, and projects designed to bring about change in the classrooms of a designated region. These efforts are accomplished through a variety of mechanisms including combinations of in-service and summer institutes.

Science faculty fellowships and research participation.—This program will permit faculty members at the less research oriented 4-year colleges and community colleges to obtain advanced graduate training and participate in meaningful research activities. It is designed to increase the quality of the science faculty members at these institutions which provide education for a large portion of the college students in this country.

Leadership specialist projects.—Leadership Specialist Projects provide opportunities through grants to colleges and universities for educators to prepare themselves for state or national leadership in science education, or for leadership in local improvement efforts. Participants undertake full-time study while on leave from their regular duties. Provision is made for (1) teachers interested in concentrating in a single discipline; (2) teachers interested in studying several related sciences, e.g., the biological and physical sciences; (3) teachers interested in preparing themselves for supervisory or consultant positions; and (4) supervisors interested in a multidisciplinary program of study.

College teacher projects.—The problem of assisting college teachers to incorporate current advances and shifts in science and science education promptly into undergraduate instruction has been addressed through a variety of projects for some years. The general approach is to bring college teachers together with colleagues and leading scientists for a period of concentrated work on substantive matters in their disciplines and on materials and patterns of instruction.

These activities have, over the period fiscal years 1953–71, reached some 40,000 individuals compared to a current level of 150,000 college teachers of undergraduates in the country.

School System and College Implementation

The objective of this group of activities, irrespective of the specific mechanism used, is to help various educational institutions to organize their resources for more efficient uses and to spread the benefits of modern educational technologies and structures. NSF support under this program element fosters the coordination of college, high school, and elementary school science education programs so as to minimize the disjunctions between successive levels. Internal changes within institutions aided by this program are expected to result from the interaction process, making the entire ladder of educational progress for students more coherent.

The program is subdivided into two major sub-elements, School System Projects, and College and University projects, which are discussed in the following sections.

School system projects.—Implementing specific curriculum changes in a school system requires a decision by the schools to train teachers and commit resources. Modern science curricula, with emphasis on laboratory and inquiry learning, place new demands on the schools while offering significant advantages in student understanding. A collaborative approach between a school system and neighboring colleges can provide the combination of subject matter expertise by college instructors and local school initiative which will help achieve the schools' goals.

College and university projects.—Included in this group are three types of projects. These are, in general, aimed at implementation of improved courses and curricula developed under NSF and other support using various techniques.

(1) "Four-year College and University Projects". These projects provide support for efforts to improve the teaching and learning of science at the undergraduate level in a comprehensive manner by looking to the total needs of the college science program at a given institution.

(2) "Ethnic Minority College" projects are designed to accelerate the development of science capabilities of two- and four-year institutions which have predominantly historically served ethnic minorities. This is a part of the Nation's effort to raise the level of science education at the target institutions.

(3) "Undergraduate Instructional Scientific Equipment Projects" provide the mechanism through which the NSF helps those institutions that have devised greatly improved undergraduate programs, but cannot implement them because of a lack of instructional equipment.

TALENTED STUDENT PROGRAM

The central objectives of the Talented Student Program are to improve the way in which education is provided by the academic institutions and to provide a reasonable and continuous flow of talented individuals into science careers. In addition to the fiscal year 1973 authorized sum of $2,800,000, it is expected that $6,000,000 of fiscal year 1972 funds will be obligated for these programs during fiscal year 1973.

High School Student Projects

The identification of future leaders and conservation of talent is one of the tangible results of this program. Both large- and small-scale evaluation studies consistently show that about 85 percent of the male and 70 percent of the female participants in this program elect majors in science for their Balchelor's degree. Studies with control groups show that former participants always exceed the control group in proportions of undergraduate science majors, of those going on to graduate school, and of those choosing science as the area of graduate concentration, and in academic performance. Indeed, as a result of this type of project, many former participants are admitted to advanced standing in their colleges and proceed more quickly thereby to their undergraduate degree.

Undergraduate Student Projects

The Undergraduate Student Projects are designed to stimulate colleges and universities to incorporate research opportunities for undergraduate students into their normal curricular patterns.

This has encouraged hundreds of science departments to think of research participation as an effective tool for science instruction at the undergraduate level, rather than as a special mechanism for teaching of gifted students.

These projects provide many smaller undergraduate science departments the only available external support for the introduction of research into the science education experience of their students. Specifically, the program provides opportunities for undergraduate students to obtain research experience, and has the added advantage of providing teaching scientists with opportunities for pursuing creative professional work with a group of highly motivated science students. The favorable impact of this experience upon the learning response of the students and upon the teaching vitality of the faculty has been conclusively demonstrated.[148]

D2. A Forgotten Agreement Not To Deal With Schools

In the Annual Report for fiscal year 1973, NSF said that further reorganization of the Education Directorate was underway:

> During fiscal year 1973, the Foundation completed an extensive examination of each of its science education improvement efforts. The conclusions reached formed the basis for decisions necessitated by the unanticipated curtailment of funds and were invaluable in the formulation of plans for a much more sharply delineated program of operation for fiscal year 1974. The program critique was accompanied by an analysis of the Education Directorate's organizational structure and a reorganization of its operating divisions to create a more effective pattern of program management which would be responsive to the new program emphasis to be found in the altered fiscal year 1973 program and the more significantly restructured Science Education Improvement program plan for fiscal year 1974.

To be sure, the entire program and budget were revamped in fiscal year 1974, to emerge in a form that appeared for the most part to be even more remote from the original concept of providing science instruction directly to teachers and students. The 1973 Annual Report also mentioned two terminations of activity. In the words of the Report:

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[148] U.S. Congress. House. Committee on Science and Astronautics. Authorizing Appropriations to the National Science Foundation. Report [To Accompany H.R. 141[illegible]8] Washington. U.S. Govt. Print. Off. 1972. H. Rept. 92-977. p. 74 ff.

> The Cooperative College-School Science Program will no longer be supported as an independent activity. The mechanism of cooperation between school systems and colleges and universities assisting them to make improvements in their courses and curricula will become a part of the curriculum implementation activities supported by the Division of Pre-College Education.
>
> * * * * * * *
>
> The Comprehensive Grants Program, which was terminated in fiscal year 1973, sought to foster a lasting interaction between colleges and universities and the teachers in the region they served. The approach was for institutions to provide in-service teacher training opportunities explicitly matched to the needs of their schools while modifying the regular programs of the sponsoring university so that they were more responsive to teacher and school needs. These changes showed evidences of persisting beyond the intended 4-year life of the grants.
>
> Two factors necessitated the termination of the program. First, funding limitations required a reassessment of NSF priorities and, as a result of that activity, *it was determined that the Foundation should support only that teacher training which fostered the implementation in schools of major course and curriculum development, a policy central to the program plan for fiscal year 1974.* (Emphasis added. The second reason was omitted from the report.)

It would appear that NSF was beginning to seek a much more active role in dealing directly with schools. If so, this would have been counter to the Foundation's long-standing "arms-length" relationship with school systems.

Once again, the descriptions of activity in the Annual Report for fiscal year 1973 revealed a new direction of effort. Under *Experimental Models and Demonstration Program:*

> REGIONAL, STATE, AND URBAN PRE-COLLEGE SYSTEMS
>
> The Foundation supported experimental projects involving the coordination of the efforts of Federal, State, and local governments, and of private agencies in meeting a specific mutually agreed-upon educational need or solving a specific problem in science education in a region such as a State.
>
> Supplemental grants were made to continue two projects: (1) for the Systems Approach to Science Education in Delaware to support its third year of operation, and (2) for the Oregon System in Mathematics Education to support its second year of operation.
>
> The Delaware project is a Statewide cooperative effort of the University of Delaware, Delaware State College, Delaware Technical and Community College, the Delaware State Department of Public Instruction, and the 26 school districts of the State. The general goal of the program is the improvement of the quality and variety of science and mathematics programs on the pre-college level with emphasis on the middle grades. The efforts of the project are concentrated in schools and classrooms rather than colleges and universities.
>
> The Oregon Project is a Statewide cooperative effort which aims to develop exemplary mathematics programs in elementary and secondary schools taking into account demography, organization, and pupil needs. Activities of the project include those designed to develop leadership personnel, improve teacher education programs, strengthen professional organizations, and improve communication among system components.
>
> A third grant was made in 1973 to assist in designing a program, utilizing systems design concepts, for ascertaining the earth science educational needs and priorities of Oklahoma and meeting those needs. The total funds obligated for the three projects was $1.0 million.

Some of the activities of the Pre-College Teacher Education sounded very much like the sort of thing that might be able to be done in a college of education:

> A project at Indiana University is developing a model program for the education of prospective elementary school teachers in the teaching of mathematics utilizing an activity-oriented laboratory setting. The experience of the prospective teachers

> includes education in mathematics teaching on the campus that totally integrates the study of content and method in a mathematics laboratory setting, and observation of how children learn and teaching experience in a model school utilizing the mathematics laboratory approach.

In retrospect, this might well have raised a question of what had become of the longstanding agreement that NSF would not deal with schools—only with teachers—and of what NSF was doing that was distinct from the Office of Education. There appeared to be no indication that this was a joint project with the Office of Education. It now seems possible that NSF was moving in directions that could have led it to duplicate certain functions of the Office of Education. Thus, there would seem to have been reason to question whether this new focus on implementation and pedagogy would be appropriate for NSF.

D3. The Task Force Study on Science Education

It should be noted that the redirections reported in the subsequent annual report for Fiscal Year 1974 indicated a distinct difference in approach and basic philosophy. This change coincided in part with the appointment of Dr. Lowell J. Paige as Assistant Director for Education, though most of the planning occurred prior to his arrival, under the direction of Dr. Raymond Bisplinghoff, NSF's deputy director.

Dr. Bisplinghoff was apparently impressed with the shortcomings and limitations of NSF's indirect approach to the improvement of science education at all levels, and may have felt obliged to respond to OMB pressures for greater effectiveness in the Foundation's education programs.

He convened a small "task force" of officials from the Foundation, from the Office of Science and Technology, and (as observers) from OMB. The purpose was to use objective analysis and programming to develop a fundamentally new approach for the Foundation's education activities. The purpose was set forth in the abstract of a "preliminary draft working paper"—a final report for distribution never having been made—entitled "Task Force Study on Science Education: Problems and Suggested Programs for consideration by the Executive Office of the President and the National Science Foundation." The abstract stated:

> In the paper, the objectives and current status of science education are reviewed to identify key problems. A logical set of programs is then developed, based on means of response available to NSF. The analysis was hampered by lack of knowledge and data both on problems and on the effectiveness of various mechanisms available to NSF for solving problems. However, the report establishes a clear linkage between problems and programs. Moreover, it provides a good framework for conducting further program analysis and development.
>
> The report recommends a shift in emphasis from science education to prepare research scientists to science education to prepare people for the wider range of occupations that demand a scientific or technical background and to increase the science literacy of the population as a whole. In addition, the report recommends emphasis on the exploitation of science and technology to improve the efficiency of science education. The technology programs recommended are directed at overcoming currently existing obstacles to the application of science and technology in education rather than addressing specific science education problems.

The report set forth educational objectives to be reached, and then provided alternative methods for NSF to make direct approaches to those objectives. The tenor was different from NSF's usual rhetoric of *laissez-faire*, and emphasized action-oriented methods. As Dr. Bisplinghoff, NSF Deputy Director, indicated in his testimony before the House Committee on Appropriations in the fiscal year 1975 appropriations hearings (see the quotations in the fiscal year 1975 discussion), this report provided the basis for the significant revision in NSF education programs which began to be implemented with the arrival of Dr. Paige as NSF's assistant director for education.

E. FISCAL YEAR 1974—POSSIBLE INFLUENCE OF OMB

By the time the hearings began on the fiscal year 1974 budget request, Dr. Stever had been in office for a full year. This was therefore the first budget prepared under his direction. Dr. Paige had not yet been appointed as Assistant Director for Education, however.

In his opening remarks to the Subcommittee on Science, Research and Development of the House Committee on Science and Astronautics to support the NSF authorization request, Dr. Stever commented as follows:

> The Foundation's program for fiscal year 1974 includes an expanded science education program, compared to the revised program for fiscal year 1973. However, I should point out, as you well know, that the revised fiscal year 1973 program was below that authorized by the Congress.
>
> As I indicated to the committee last year, at that time the Foundation was in the process of making a detailed analysis of its education program to determine how each of the elements of the program was contributing to identified science education needs. That analysis revealed that a number of National Science Foundation science education programs had either largely achieved their objectives or were not effective in terms of addressing the science education problems of the 1970's. For example, curriculum and course development work in single disciplines was not helping the science student to learn how to cope with real world situations requiring an interdisciplinary problem-solving approach. Programs exclusively designed to turn out more research-oriented Ph. D.'s were aggravating the oversupply problems in certain areas, and some programs were not proving to be effective because there was no system for implementing improved instruction techniques in the school systems.
>
> So the Foundation's restructured science education program for fiscal year 1974 is designed to:
>
> First, find ways to improve the effectiveness of science education through the application of modern educational technology and new methods of instruction;
>
> To provide for the numbers, variety, and flexibility of scientific and technical manpower needed to meet the Nation's changing requirements for trained scientists and engineers as practitioners, in addition to researchers in industry, Government, and other sectors of the economy;
>
> To make the general public more knowledgeable about the potential uses of science and its limitations so that they can deal more effectively with problems requiring a science and engineering input; and
>
> To help meet the requirements of scientists and engineers for continuing education.
>
> The restructured program provides the basis for the National Science Foundation to make significant contributions to national efforts aimed at finding more effective ways to deliver educational services to students at the college and precollege levels. The program supported by the Foundation will be at the forefront of science education in that it will be attempting to develop new and innovative approaches to the implementation and conduct of science education programs at all academic levels. Here again we have found that the science education problems of the 1970's demand new and innovative approaches, and research must be performed to provide a sound basis on which to proceed.[149]

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[149] U.S. Congress. House. Committee on Science and Technology. Subcommittee on Science, Research and Development. National Science Foundation Authorization for 1974. Hearings, 93rd Congress, 1st session. Washington, U.S. Govt. Print Off. 1973. p. 46, 47.

Shortly thereafter, Congressman Esch voiced a concern that others on the subcommittee would allude to later on. Speaking to Dr. Stever, he said:

> Mr. Esch. * * *
>
> A major concern of this committee has been the question of science education and we are certainly glad to see that your preoption was in the area of science education. To a degree the concern I have is that in spite of the fact that this committee's emphasis has been on science education: science education funds were left in the budget unexpended. Within the last 2 or 3 years we have been running what perhaps might not be a very politically sensitive battle in this area.
>
> We see now that we are at $58.9 million in terms of carryover funds to be used in fiscal year 1974 and I think there are probably $2½ to $3 million floating around in addition to that. We have about $40 million in funds which have not been expended by NSF on science education programs of 1973 funds.
>
> I reflect, I think, the concern of the committee on the failure to expend those funds, in spite of a mandate from the committee, but especially in light of your conclusion in your testimony, and in light of the testimony that was read by Dr. Heyns for Dr. Carter, which says specifically that students pursuing advanced degrees in the sciences and engineering have been steadily declining since 1963. There is a suggestion in your testimony that, indeed, we may be entering into a new phase where we need an increase in funding in those areas. I think the committee would be very happy to work with you in any restructuring programs, but I wonder if you would want to talk about why the $39.8 million has not been expended and/or what other alternative plans you have in that area? [150]

Then Mr. Esch raised another important question:

> Mr. Esch. There is a concern I have had which is reflected in two areas. One is that you are suggesting, and most of us recognize, the need to develop multidisciplinary approaches, especially within our educational institutions. At the same time, it is a major burden taken on by NSF to accept the responsibility for making a determination of what those multidisciplinary improvements will be. I would hope in the detailed testimony we can get into the question of how much decisionmaking should be made from a central source as opposed to allowing and continuing to allow diversity in the field. I am very much concerned toward that trend.
>
> Dr. Stever. We are concerned about that also. Of course, the National Science Foundation uses far greater participation by the community, by the education community, and the science community than most Government agencies. As you know, through the fact that when we announce a major program such as a diversification goal, we still do not fill in all the details. We get proposals from universities and other units to work toward this goal and then we essentially run a contest to judge them and get what are judged as the best.[151]

Evidently there were some important issues on the minds of the subcommittee members. First, the Office of Management and Budget seemed to be countermanding the specific instructions of Congress by selectively reducing, by impoundment, NSF funds for education, in contrast to enforcing an overall or pro-rated general reduction in all categories of the NSF budget. Second, the preparation and development of the new multidisciplinary curricula required that the developers make a selection of material and of subject areas, and Mr. Esch seemed concerned about whether this constituted undue Federal influence on the curricula of local schools as an indirect result of such choices.

It remained for Congressman Mosher, the ranking minority member of the subcommittee and a man who had displayed a supportive and creative interest in NSF for many years, to articulate one of the more fundamental aspects of the suspected OMB influence on the NSF education program. In the midst of the discussion about the overall restructuring of the Education Directorate, Mr. Mosher asked for recognition to address a question to Dr. Stever and to Dr. Raymond L. Bisplinghoff, NSF Deputy Director, who was testifying:

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[150] Ibid., p. 48.
[151] Ibid., p. 49.

> Mr. Mosher. Mr. Chairman.
>
> For some reason I find this discussion terribly unsatisfactory and frustrating.
>
> Let's go back to the present philosophy of the National Science Foundation in the field of science education. As I understand it, you and Dr. Bisplinghoff are asserting that your emphasis must be an innovating role. And that once you have innovated a program to the point where it is being really very useful and effective and creative, then you drop it, and the sustaining role, I think Dr. Bisplinghoff said, the sustaining role has to be picked up by some other agency.
>
> Dr. Bisplinghoff. Yes.
>
> Mr. Mosher. Well, now, has this always been true? Has this always been the philosophy of the National Science Foundation, or is this of new rationalization to excuse the budget cuts required by OMB?
>
> And if, say, just to cite an example of the equipment grants, which presumably were an innovative program at one point and useful, and colleges began to find them useful and depend upon them to some extent, but now they are dropped "boom," and someone else is supposed to sustain the Federal support of those programs, and I don't think that is a particularly good example, I think there are others that might be better.
>
> Who is supposed to do this? Is it HEW, or is—Dr. Bisplinghoff, you mentioned, I think, other agencies should pick up these programs once that they have been innovated.
>
> Which agencies should pick them up?
>
> Dr. Bisplinghoff. HEW would be the primary agency that would be involved.
>
> Mr. Mosher. Is there any consideration by HEW of picking up these undergraduate programs that are being phased out?
>
> Do you know of any specific consideration of that? Is Dr. Stever in his new role as science adviser, is he urging the White House—this is unfair for me to ask of Dr. Stever, because he assumed this role so recently I know.
>
> But as science adviser is he going to be pressing George Shultz and the White House to live up to the commitments that President Nixon made in his rhetoric of 4 or 5 years ago, and again last year, that science education must be vigorously sustained, and thus is he encouraging, is he saying National Science Foundation is being cut so someone else has to pick this up and it should be HEW? You can't answer that question I know.
>
> Dr. Bisplinghoff. No, I can't answer what he will do eventually, but I could envision that as one of his goals.
>
> Mr. Mosher. I would hope so. I think Dr. Stever, and the National Science Foundation have a tremendous opportunity in the President's new strategy, if you want to call it that, in the dismantling of the science apparatus at the White House level.
>
> I would hope that the National Science Foundation people can point to the innovative successes they have had, and urge other agencies to pick these programs up and support them, if NSF can't.[152]

E1. Congress Supports NSF Education at all Levels

While the Congress could not control the form of the budget submitted to it, it did take steps to make its views known and to force release of NSF education funds that had been impounded. The authorization report of the House (H. Rept. 93–284) stated:

> The Committee restates its strong interest in the continuing support of the National Science Foundation programs of Science Education at the primary, secondary, undergraduate and graduate levels. This support is reflected in a tangible manner in the funding increases for the Graduate Student Support and Science Education Improvement budget categories.
>
> The fiscal year 1973 authorization Act amended the NSF Organic Act of 1950 in order to emphasize the responsibilities for Science Education which are assigned

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[152] Ibid., p. 533, 534.

by statute to the Foundation. The Committee originated those amendments and emphasize again its strong support for a viable NSF program of Science Education at all levels.[153]

In addition, the Authorization Act (Public Law 93-96, 93rd Congress, H.R. 8510) stipulated as follows:

> SEC. 2. (a) Any amounts which were authorized and appropriated to the National Science Foundation for the fiscal year ending June 30, 1973, or any prior fiscal year, but which remained unobligated as of the close of the fiscal year ending June 30, 1973, shall be merged with and added to the amounts authorized by section 1 of this Act.

The issue was not simply the money. Rather, the issue appears to have been the use of impoundment to manipulate the NSF education programs under the guise of fiscal responsibility. The act also stated:

> SEC. 2. (b) Notwithstanding any other provision of this or any other Act—
>
> (4) of the total amount authorized under section 1 and subsection (a) of this section, not less than $13,000,000 shall be available for the purpose of "Graduate Student Support"; and
>
> (5) of the total amount authorized under section 1 and subsection (a) of this section, not less than $67,500,000 shall be available for the purpose of "Science Education Improvement".

E2. Education Termed "A Lesser Priority" by National Science Board Members

The House appropriation hearings put the matter in slightly different focus as Congressman Giaimo inquired about who sets NSF priorities and discovered that neither Dr. Carter nor Dr. Heffner, the two National Science Board members who had accompanied Dr. Stever to support the appropriation request, was willing to accord a high priority to the NSF education budget. The discussion included many details about what amounts of money had been impounded, but the issue was raised as follows:

> Mr. GIAIMO. I want to comment briefly and ask a few questions right now, Mr. Chairman, and then later we can get into the budget. In general, I have the highest respect for the National Science Foundation and for Dr. Stever. Unfortunately I think you, like Congress and many other people, are becoming captives of parts of the government, specifically the OMB. I am most unhappy about that, and I hope that some of you in the NSF are too.
>
> My unhappiness, as I think Mr. Roush expressed earlier, and I think Mr. Tiernan touched on it, is not directed at you. Who is running our agencies now and who is making the decisions? Do you make the decisions or does OMB make them for you? Whether you, Doctor, or members of the Board want to respond to that, I would like to know. Before you answer let me preface by saying this. For several years now Congress, and particularly the legislative committee and specifically also this committee, have mandated the National Science Foundation to carry on its great functions in institutional support for science, graduate students, support in all those areas. Those funds, to my knowledge, have been impounded. They have not been used. Your efforts have been cut back, and I am not convinced that this is your decision.
>
> What is the sense for Congress, which is supposed to pass the laws for the people, and be the peoples representatives, what is the sense year after year coming in here, insisting that you do these things and yet they are not done, and the funds are impounded? I would like some comments from either you, Doctor, or any of the distinguished gentlemen whom we have here. Where are we going?
>
> Dr. STEVER. Mr. Chairman, I will be glad to say a few words on this. Of course, the NSF, as I pointed out to Mr. Roush, asks for the apportionment of the funds

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[153] U.S. Congress. House. Committee on Science and Astronautics. Authorizing Appropriations to the National Science Foundation. Report together with additional views [to accompany H.R. 8510]. Washington. U.S. Govt. Print. Off. 1973. H. Rept. 93-284 p. 122.

exactly as this appropriation committee legislates them. This last year the President considered it absolutely necessary to cut back in the operation of all of the Federal agencies because of the very tough fiscal crises faced by the Nation.

In looking at how NSF fared in the cutback, the major cutback came in the area where we are undergoing program reorientation, the science education improvement program. We are changing its objectives, as I explained this morning. It was perhaps the most vulnerable to a cutback.

It would certainly be helpful to somebody like me and the NSF staff if in times when an axe has to fall, further conversation on priorities of reductions might be in order.

We have an annual meeting to develop priorities, but we don't have one in the middle of a year, when there is a sudden change. As I am sure you know, it is difficult for us, and of course the administration knows it is difficult for us, to adjust to one of those sudden changes. I do think that anyone looking at our total budget would say that when we have to tighten the belt, we ought to look at all of our programs and see what the different priorities are, and then tighten around the lesser priorities.

Mr. GIAIMO. I am going to ask you the same question we asked Mr. Ash and Mr. Shultz a couple of weeks ago. Who determines what is a lesser priority?

Dr. STEVER. That is clearly one of the major problem areas in our Government process.

The discussion was diverted momentarily, and then returned to Mr. Giaimo's point:

Mr. GIAIMO. I know. Where was the $60 million impounded, can you tell us?

Dr. STEVER. The unapportioned fiscal year 1973 funds in the science education improvement program was $33.8 million of funds appropriated for that line item.

Mr. GIAIMO. Not only appropriated, but if I remember the language of the record in the appropriations bill, you were specifically told by the Congress and by the legislative committee to maintain your levels in those areas.

Dr. STEVER. That is correct.

Mr. GIAIMO. Yet OMB cut out $33.8 million, is that correct?

Dr. STEVER. $33.8 million in that area.

Mr. GIAIMO. What is the rest of the $62 million.

Mr. STEVER. There was a drop of $8.7 million in RANN, in the energy and earthquake engineering. Institutional improvement carryover into fiscal year 1974 is $9 million.

Mr. TALCOTT. Graduate student support.

Dr. STEVER. Graduate student support carryover from fiscal year 1973 was $6 million. Those are the ones that have the floors.

Mr. GIAIMO. So it is fair to say then that most of the $60 million——

Dr. STEVER. Is in the programs with legislative floor.

Mr. GIAIMO. Specifically is in the category where Congress said don't cut, and OMB said "here is where you cut."

Dr. STEVER. That is correct.

Mr. GIAIMO. Which brings me to the point frankly, and again I preface this by saying I am not finding fault with you or NSF, but it brings me to the point that I literally wonder as an elected representative of the people why I am even wasting my time sitting in these hearings day after day and year after year, when Congress says something and apparently OMB says otherwise, and Congress seems to be totally ignored. I would like some comments on this, as I say, from you or the Board. Perhaps the Board should comment.

Dr. STEVER. I think the Board might. I really have commented. I believe I would like to see a system worked out by which the proper priorities can be given, and in the light of changing circumstances on the total budget we can get an agreement on how to do it.

Mr. GIAIMO. Does anyone want to comment?

Dr. CARTER. I would say that the Board has, on rather rare occasions in the past and on points where it was really most drastically concerned, gone to OMB for discussions with them. I must say that there seems to be no very effective way other than just constantly to come back with the things that we consider important. Our concern about instrumentation did result in some reaction from OMB.

Mr. GIAIMO. Let me interrupt you there. You say we think they are important. Does the Board or members of the Board think that these are lesser priorities? I can find many people for you in the educational community who do not think they are of a lesser priority. Does the Board feel they are lesser priorities?

Dr. HEFFNER. I suspect you are going to find differences of opinion on the Board as you do in the outside world, but for myself I think these are the lesser priorities.

Mr. GIAIMO. But at least there are some on the Board who do not think that.

Dr. HEFFNER. I suspect there are.

Mr. GIAIMO. We poor Congressmen are not voices in the wilderness, is that right?

Dr. STEVER. That is correct.

Mr. GIAIMO. Because certainly when you go outside the Board in the educational community we find plenty of support for the proposition that these are not lesser priorities.

Dr. HEFFNER. They tend to be the recipients.

Dr. CARTER. The Board has looked at priorities in the light of total resources. Basic research always has had the highest priority as indeed I think it should. If that takes a major portion, then the question is how you allocate the remaining funds.[154]

E3. Congress Replies

In its report (H. Rept. No. 93-296), the committee specifically did not object to the restructuring of the institutes and the setting of new goals for the education programs. But it did support the education appropriations quite strongly:

> * * * * * * *
>
> The bill also includes limitations of $29,000,000 for program development and management; $5,000 for official reception and representation expenses; $65,000,000 for Research Applied to National Needs; not less than $14,000,000 for graduate student support; and not less than $69,000,000 for science education improvement.
>
> Although the appropriation recommended is a modest decrease from the budget request, the amount provided is sufficient to continue most program activities at the same or higher levels than the 1973 budget plan.
>
> The individual actions taken in the bill and report reflect many of the same concerns expressed by the Committee in past years. These actions are designed to insure that applied research is not pursued at the expense of basic research, and that both applied and basic research are not pursued at the expense of the science education responsibilities of the Foundation.
>
> * * * * * * *
>
> Science education continues to be a matter of concern to the Committee. The Committee is not satisfied with the efforts of the Foundation and the National Science Board to recruit and develop high quality science teachers at both the secondary and college level. Although the Committee has no objection to instituting new science education techniques, it does object to the NSF requesting a specific level of funding for science education, which the Congress ultimately appropriates and even earmarks, but one-third of which is immediately impounded and left unused. This action reflects both a lack of faith and a lack of planning on the part of the Foundation and the Office of Management and Budget.[155]

The Appropriation Act (Public Law 93-137; 87 Stat. 491) included minima of $12.5 million and $65 million for Graduate Student Support and Science Education Improvement respectively.

E4. The New Philosophy and Operation

The NSF Annual Report for fiscal year 1974 revealed some interesting changes in focus, although the budget became so completely reordered and restructured that it is very hard to make a comparative study of how funding levels of various activities had changed. In the

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[154] U.S. Congress. House. Subcommittee of the Committee on Appropriations. Hearings, 93rd Congress, 1st session. HUD-Space-Science-Veterans Appropriations for 1974. Washington U.S. Govt. Print. Off, p. 52 ff.

[155] U.S. Congress. House. Committee on Appropriations. Department of Housing and Urban Development; Space, Science, Veterans, and Certain Other Independent Agencies Appropriation Bill, 1974. Report together with supplemental views [to accompany H.R. 8825]. Washington. U.S. Govt. Print. Off. 1973. H. Rept. 93-296. p. 17, 18.

Director's Statement preceding the text of the report, Dr. Stever described the overall education effort as follows:

> Our Science Education Improvement Programs are centered around three major thrusts: the improvement of science education for those who seek careers in science; its improvement for scientific literacy—for those who will need a better understanding of science even though they are not entering scientific careers; and the improvement of the efficiency and effectiveness of the educational process itself. These efforts should help to supply the well-trained scientific and technical manpower the Nation needs, while at the same time giving us leaders, managers, and citizens better able to conduct the affairs of a society increasingly dependent on wisely used science and technology.

The formal structure of the program was indicated by the following program listings:

Science Education Improvement

IMPROVEMENT OF EDUCATION FOR CAREERS IN SCIENCE

Secondary School Program
- Materials Development, Testing and Evaluation.
- Instructional Improvement Implementation.

Student-Oriented Program
- Secondary School Student Projects.
- Undergraduate Research Participation Projects.
- Student-Originated Studies Project.

Alternatives in Higher Education Program
- Development of Instructional Materials.
- Alternative Degree Projects.
- Technician Education Projects.
- Instructional Scientific Equipment.
- Visiting Foreign Energy Scholars.

Continuing Education and Professional Development
- Continuing Education for Scientists and Engineers.
- College Faculty Short Courses.
- Faculty Research Participation.
- Science Faculty Fellowships.

Ethnic Minorities in Science

IMPROVEMENT OF EDUCATION FOR SCIENCE LITERACY

Elementary School Program
- Materials Development, Testing and Evaluation.
- Instructional Improvement Implementation.

Secondary School Program
- Materials Development, Testing and Evaluation.
- Instructional Improvement Implementation.

Public Understanding of Science

INCREASING EFFECTIVENESS OF EDUCATIONAL PROCESSES

Technological Innovation in Education

Educational Program Restructuring
- Pre-Service Teacher Training Projects.
- Restructuring the Undergraduate Learning Environment Projects.
- State/Regional Urban Systems Projects.

PROBLEM ASSESSMENT AND EXPERIMENTAL PROJECTS

Problem Assessment and Experimental Projects

Minorities and Women Student Projects

The fellowships and traineeships were in a separate program, as begun in fiscal year 1971:

GRADUATE STUDENT SUPPORT

Graduate Fellowships.
Graduate Traineeships.
Energy Related Post-Doctorals.

The Annual Report for fiscal year 1974 outlined the major concepts of the reorganization as follows:

"Fiscal year 1974 marked the first full year of operation of the NSF Education Directorate's restructured program of Science Education Improvement activities. While earlier NSF education activities have had a marked effect on science education in the United States—and many countries abroad as well—some of the problems toward which they were directed, such as a general shortage of scientific research manpower, now have been reduced, to be replaced by others of growing importance. Certain of these probiems have been identified as being relevant to the Foundation's mission and capabilities.

"The changing nature of our society and its economy has created a need for a range of scientific and technical competencies well beyond those possessed by individuals whose academic preparation is primarily for pursuit of careers in basic research. The student body of the Nation's schools, colleges, and universities is much more varied now than in previous generations. Institutions just be responsive to a broader spectrum of student abilities, talents, and needs.

"The increasing technology-based character of both the production and service sectors of the economy requires that all citizens, nonscientists as well as scientists, have an understanding of the impact of science and technology on their careers as well as their daily lives. The rate of change has become so rapid that obsolescence with respect to employment imposes a need for continuing education in many forms for many people. The increasing costs of education require research into and implementation of more effective kinds of organization and management structures and instructional methods at all levels of education. New ways must be found to bring the results of research and experimentation into direct, regular use in schools and colleges.

"In recognition of these factors, the major objectives of the Foundation's fiscal year 1974 Science Education Improvement activities were to:

> "Help assure the National of an appropriate variety, flexibility, quality, and amount of scientific and technological manpower with greater participation of minorities and women.
>
> "Improve science education to: (1) meet the needs of a broader range of students; (2) increase substantially the number of persons who make effective use of the processes and results of science in their work and personal lives (whether or not they are engaged in scientific or technical occupations) and who understand public issues involving modern technologies; (3) develop and implement new instructional strategies and methodologies; and (4) disseminate the knowledge gained from research on the processes of learning and education.
>
> "Find ways to increase the impact and effectiveness of the Foundation's Science Education Programs through research and problem assessment which can point to necessary future program directions.

Program activities were structured around four major themes:

"Improvement of education for careers in science
Development of science literacy
Increasing the effectiveness of educational processes
Problem assessment and experimental projects.

Descriptions of activities under the main headings were as follows. The discussion is omitted where it did not pertain to pre-college education. The lack of definition in certain areas may have been due to NSF's interest in letting proposals determine many programs.

IMPROVEMENT OF EDUCATION FOR CAREERS IN SCIENCE

Program support activities in fiscal year 1974 were addressed not only to the problem of maintaining the quality of training in the traditional science disciplines, but also to the development of new, flexible instructional patterns leading to a wider variety of scientific and technical career options. Efforts supported in fiscal year 1974 included course material development and implementation at the secondary through continuing education levels, as well as some experimental models at undergraduate and higher levels. Another approach to curricular change was through the Student-Oriented Program, aimed at demonstrating the value of increased student research participation in the learning process. The Ethnic Minorities and Women in Science program was created to find ways to increase the disproportionately low number of people from these groups who form a portion of the Nation's scientific and technological manpower supply.

SECONDARY SCHOOL PROGRAM

Since motivation toward a scientific career or one in a technological support area first becomes evident in most children during the adolescent years, it is essential to give attention to this phase of a student's development. Much of the support given by the Foundation in curriculum development in the 1960's was directed more toward the academically oriented, potential science student than toward the student with less specialized interests. Therefore, a relatively small portion of the NSF education allocation has been spent in this program for the past 3 years, with the major effort shifting to science literacy to compensate. However, funding was continued in fiscal year 1974 for the Biomedical Interdisciplinary Curriculum Project, which is designed for the potential biomedical technologist. Other current curriculum development projects contain significant career-oriented portions, usually as modules or units probing a subject in greater depth, which can be focused on the potential scientist.

Implementation activities are more fully described in the Science Literacy section of this report. In fiscal year 1974, 11 implementation projects supporting 610 secondary school teachers and resource personnel were devoted exclusively to advancing the student oriented toward an eventual career in science. These projects were involved principally in aiding school districts to introduce new mathematics curricula in their high schools through the provision of special training in the use of the new instructional materials and methods.

ALTERNATIVES IN HIGHER EDUCATION

CONTINUING EDUCATION FOR SCIENTISTS AND ENGINEERS

STUDENT-ORIENTED PROGRAMS

ETHNIC MINORITIES AND WOMEN

GRADUATE STUDENT SUPPORT

DEVELOPMENT OF SCIENCE LITERACY

The Education Directorate's fiscal year 1974 emphasis on science literacy recognized the importance of increasing attention being given to the problems of improving the general level of scientific literacy of a broader segment of the population.

The goal of the science literacy activity is to increase substantially the number of persons who are able to make use of the methodologies of science as well as the results of scientific discovery, in their work and personal lives, whether or not they are engaged in scientific or technical occupations.

As our society becomes more and more technologically oriented, more individuals are becoming engaged in activities or in making decisions that require a scientific or technical background, and there is an increasingly wide range of jobs at all levels for which science training is highly useful, if not essential.

Concurrently, the Nation desires to make the benefits of more education available to more of its citizens. Our schools are now accommodating almost the entire school-age population and thus are faced with an increasing diversity of talents, capabilities, and career aspirations. To meet the needs of these students a wider variety of teaching materials must be developed, including materials that can be matched to the learning abilities of both the theoretically inclined student who learns readily from the printed page and the more practically oriented student who learns best from "hands-on" materials and tangible models.

ELEMENTARY SCHOOL PROGRAM

Materials and Instruction Development

In mathematics, four conference reports, available as a result of fiscal year 1973 activities, provided a partial reassessment of mathematics education in the country and pointed directions for the Foundation's next steps in attempting to attain mathematical competence among the Nation's students. In response to the major recommendations of these reports, a number of grants were made, all designed to study more closely the teaching and learning process. Two of these, one to Eugene Nichols at Florida State University, the other to George Springer at Indiana University, will provide for development of materials at the elementary school level that should overcome some of the difficulties recently encountered in using content from earlier development efforts along with a close study of children's performance in the new materials. The use of Teachers' Centers as reinforcement for the teaching process is being investigated at Southern Illinois University, the University of Denver, and the University of Wisconsin at Whitewater, Investigations of mathematical learning in children are being undertaken by Edward Begle, Stanford University; Joseph Scandura, Research for Better Schools, Inc.; Robert Davis, University of Illinois; Max Bell, University of Chicago; and Hassler Whitney, Institute for Advanced Studies, Princeton.

Additional funds were made available for the combined science-mathematics project Unified Science and Mathematics for Elementary Schools (USMES), directed by Earle Lomon of MIT, at the Education Development Center. This This project is nearing the end of its development phase and moving rapidly into implementation. Another aspect of the elementary school program is illustrated by a grant to Antioch College for an impact assessment of the elementary social studies course, Man: A Course of Study.

Instructional Improvement Implementation

A major restructuring of implementation activities at the pre-college level was accomplished in fiscal year 1974. Attention is now focused principally on bringing innovative curriculum materials into the classroom and orienting the educational staff of schools and school districts in the appropriate use of the materials they have chosen. Implementation grants are categorized as: (1) orientation of educational leaders—involving teams from selected regions to become thoroughly familiar with one or two of the major curriculum projects supported by NSF so that local training can be handled by members of these teams, and familiarizing education system decisionmakers with new curriculum developments to increase their understanding of their options for improvements of instruction in the sciences and in mathematics; (2) school system-centered projects – for school systems committed to full implementation of one of the new curricula in their classrooms, in collaboration with local colleges to strengthen the quality of teacher training; and (3) teacher-centered projects—to permit individual teachers who have leadership roles in their own schools or school systems to gain thorough background in one or two curricula so that they may try out the materials in their local situations prior to a commitment for widespread adoption.

This year grants were awarded costing $5.9 million for elementary school implementation activities. A total of 17,587 teachers, supervisors, and other resource personnel in science and mathematics participated in 157 projects.

SECONDARY SCHOOL PROGRAM

Materials and Instruction Development

The mathematics developments described under the Elementary School Program extend to the secondary school level. Grants to Boston University (Uri Haber-Schaim, Director) and the University of Oregon (Alan Hoffer, Director) will provide prototpye materials in addition, an analysis of mathematics achievement of secondary school students will be performed through the Conference Board of the Mathematical Sciences.

In the social sciences a behavioral science curriculum project has been initiated with an award to the American Psychological Association; the director is John Bare, of Carleton College. The development phase of the interdisciplinary course *Exploring Human Nature* is being terminated with this year's grant, and activities to aid implementation of the materials in schools and school systems have begun. The political science project *Comparing Political Experiences* was awarded additional funds for further development of instructional materials.

Interdisciplinary content characterizes current projects for materials development in the sciences. For example, the *Individual Science Instructional System*, started in fiscal year 1973, received major funding this year for development of interdisciplinary modules for grades 10 to 12. The *Human Sciences Program* combines material from the biological and behavioral sciences for the middle school.

In order to aid in the dissemination of information about new instructional materials and methods, a new edition of the booklet *Course and Curriculum Improvement Projects* was published by the Foundation in fiscal year 1974. This booklet describes all of the significant projects, conferences, and studies dealing with course materials and instructional development since the inception of these activities in NSF. All pre-college grade levels are included in this publication.

Instructional improvement implementation

Restructured implementation activities funded under this program are the same as have been described above under the Elementary School Program. They were supported by 246 grants at a cost of $8.8 million. A total of 17,860 teachers and other resource personnel in secondary school science and mathematics were supported through these implementation projects to aid in bringing innovative curriculum materials into secondary school classrooms.

Increasing Effectiveness of Educational Processes

While the question of cost-effectiveness is a consideration in all science education grants, the Foundation supports two major approaches to attaining a better balance between costs and educational productivity. One, technological innovation in Education, involves support of the application to the educational process of technological devices such as computers and television; the other, Educational Program Restructuring, focuses on a few major models of new approaches to the organization, management, and delivery of the content of education.

TECHNOLOGICAL INNOVATION IN EDUCATION

Support has been provided for the development and field evaluation of technologies, techniques, and systems of instruction at all levels of education.

Two and one-half years ago, the Foundation committed itself to developing and field-testing two markedly different systems of computer-assisted instruction (CAI): the PLATO (Programmed Logic for Automatic Teaching Operations) system, designed to serve as an instructional computing utility for many hundreds of students at all levels of education, using radically innovative technology; and the TICCIT (Time-Shared Interactive Computer Controlled Information Television) system, designed to provide cost-effective CAI in mathematics and English to a cluster of roughly 100 community college students simultaneously, using minicomputers and television technology.

Good progress was made in both the PLATO and TICCIT projects during fiscal year 1974. Over 500 PLATO plasma panel student consoles have been installed, and it appears that the University of Illinois PLATO system will be serving nearly 1,000 consoles by 1976, the termination date for the field-tests which start in September of 1974. The system has been demonstrated extensively in the United States and abroad (including an extensive, invited demonstration in Moscow in 1973), and is widely regarded as a singular technological accomplishment. More than a dozen corporations have announced their intentions to market devices based upon the PLATO technology, and many universities have procured consoles for their own use.

The MITRE Corp., contractor for the TICCIT system and field-test, has built and installed a small system at Brigham Young University, where the CAI lessions are being prepared. A complete system was installed in the summer of 1974 at the TICCIT field-test sites in Arizona and Virginia. TICCIT has also attracted a good deal of interest and attention in the United States and abroad. The U.S. Navy has purchased one system, and may purchase a number of them if TICCIT's performance objectives are met. The first field use of TICCIT began in the fall of 1974, and will continue through the spring of 1976.

The TICCIT system, based as it is upon television techhnology, is also being considered as a delivery system for CAI and other interactive services into the home. During fiscal year 1974. MITRE completed an extensive study of the feasibility of such an undertaking and published a seven-volume report of the findings.

Support was also provided during fiscal year 1974 for especially promising applications of technology for educational purposes,. For example, support was continued at several locations for the development and study of technologically based mathematical laboratories. Seymour Papert of MIT is applying principles from artificial intelligence theory, as well as computing technology and simulations, to instruction in mathematics, science, and music in an experimental elementary school. Thomas Dwyer of the University of Pittsburgh is developing a computer-based mathematics laboratory at the high-school level, and Alfred Bork of the University of California, Irvine, is studying the use of computer graphics for instruction in physics at the level of higher educaton.

Support was also provided during fiscal year 1974 for an extensive field-test of a system of interactive guidance and information (SIGI), to be conducted at several community colleges. This system promises to be a very useful tool not only for developing decisionmaking skills, but for studying students' decisionmaking processes as well. SIGI has been developed by Martin Katz of the Educational Testing Service, which is located in Princeton, N.J.

EDUCATIONAL PROGRAM RESTRUCTURING

Educational Program Restructuring aims to improve effectiveness and efficiency in science education through the design, development, and evaluation of major models encompassing the organization, management, delivery, and content of education. The program involves three prinicpal areas of effort: preservice education of science teachers; State, regional, or urban systems of science education; and restructuring the undergraduate learning environment.

Pre-Service Teacher Education funds were devoted to continuing support of eight projects and initiation of evaluation activities at four major projects. Earlier evaluations have resulted in withholding the funds originally intended for the later stages of a few of the projects. Current evaluation, which has a more positive goal, aims at identifying and documenting the outstanding features of four of the projects to facilitate their transfer to other institutions. A "third party" evaluation (by persons other than project staff or NSF staff) has been completed that shows that the Purdue program enhances the intellectual growth of students. The Indiana University project, being implemented on some 30 other campuses is the subject of an extensive third party evaluation.

During fiscal year 1974 the Foundation made 10 awards, totaling over $2.6 million, for systems projects. These are experimental projects which are attempting to find more effective means of coordination among all the agencies and institutions involved in pre-college science education within a specified region. Statewide projects were continued in Delaware Oregon, and Oklahoma, with the general goals of improving the quality of science, mathematics, and earth science instruction respectively. Two new projects, initiated in New York City and Lakewood, Colo., are working to develop models for improving science instruction at the middle-school level and for a computer-managed system for mathematics instruction, respectively. Third part evaluation of systems projects was begun with a grant to Western Michigan University to study the Delaware and Oregon projects.

PROBLEM ASSESSMENT AND EXPERIMENTAL PROJECTS

The Problem Assessment and Experimental Projects program was begun in fiscal year 1974 to initiate studies and experimental projects on specifically identified problems in science education. The program's aims are: to gain knowledge about possible solutions to specific problems and to explore and develop techniques to alleviate those problems; to formalize an analytical and quantitative approach to program and project evaluation and planning, and to synthesize the results of problem assessment studies and experimental projects to provide guidelines for the creation of program alternatives responsive to projected as well as current needs of the science education community.

Problem areas in which staff-identified studies were initiated in fiscal year 1974 included:

Current state and effectiveness of continuing education in the United States for nonacademic scientists and engineers,

Barriers to the movement of women and ethnic minority group members into science and technology careers,

Barriers to implementation of newly developed teaching materials and modes of instruction, and

Effective means of moving new knowledge from the research community into undergraduate classrooms.

The staff-identified experimental projects areas included:

Developing techniques to increase the number of ethnic minority group members and women in science and,

Increasing availability of high school student project activity as an integral part of high school science programs.

F. FISCAL YEAR 1975—PRELUDE TO DIFFICULTY

Fiscal year 1975 marked an extension of fiscal year 1974. Impoundment was a threat, but no longer the predominant issue. Anti-impoundment legislation of the previous year had taken care of that. But the Office of Management and Budget had come to be regarded by some people as a non-accountable entity, beyond the reach of Congress, apparently working to thwart Congressional directives relating to the support of science education. Though records of discussions of the matter by NSF offiicals with OMB have not been presented publicly, the general view seemed to be that OMB was probably a source of trouble. On the other hand, there were people in a position to know who insisted that the re-structuring of the NSF education programs was not at the behest of OMB, though the selective impoundment of education appropriations seemed to be so. The testimony of Dr. Paige and Dr. Bisplinghoff in the Fiscal Year 1975 House appropriations hearings contrasted sharply with what other NSF officials had stated or implied in the hearings of the previous year:

Dr. PAIGE. * * *.

For 20 years, we have been supporting institutes for high school teachers. In that period of 20 years, if you estimate 270,000 high school teachers, we probably reached 50 percent of them. We found in the last few years that we were not reaching that other 50 percent; and not only that, we were finding that even those teachers who went to the institute and received additional training were not always successful in introducing new curriculum when they returned to their schools.

For various reasons, the new curriculum materials were not being implemented. Therefore, the newer philosophy was to concentrate on the implementation of these new courses; that is, not on summer institutes that are going to provide opportunities to just increase subject matter knowledge, but summer programs which direct themselves at the implementation of the new material in the high schools. This also occurs under science literacy in the elementary schools.

This is one example of a program that has changed considerably in its context. Another one you will find under "Education program restructuring," where we used to have programs in which we supported largely individual efforts at the college level to improve science education. It was found that this alone doesn't provide for transferability. Therefore we seek to assist an institution, put a lot of effort into it. and see if it yields an example for other schools to follow. We have cooperated in one example in Texas with the Endowment for the Humanities, and the school completely changed the whole structure of their undergraduate effort.

We are concentrating more on larger projects rather than individualized ones. I have indicated two examples of the sort of changed emphasis which actually occurred. Do you want another one?

Mr. TIERNAN. No; I think that will be sufficient for the time being. Was it necessary to terminate the old programs or could you have kept those old programs and added the new ones to supplement them?

Dr. PAIGE. Well, our funds were limited and a choice had to be made.

Mr. TIERNAN. But it could do irreparable harm if in fact it doesn't work out.

Dr. PAIGE. I think the objectives that we seek are better served with the present programs.

Mr. TIERNAN. Was this a decision made by NSF, or was it recommended by OMB?

Dr. PAIGE. There was a decision made in an internal review of the National Science Foundation, Education Directorate; a report in 1970 from the Advisory Committee to the Education Directorate, and then a joint review by the National

Science Foundation, the Office of Management and Budget, and the Office of Science and Technology. Dr. Bisplinghoff, you were here during that review?

Dr. Bisplinghoff. Yes, I chaired that review. It was a committee that we put together inside the administration. It included the OST which existed at that time, the OMB, and the National Science Foundation, so these decisions that led to restructuring the program were arrived at jointly by that group of people.

Mr. Tiernan. Who initiated it?

Dr. Bisplinghoff. We initiated it.

Mr. Tiernan. OMB did not make any suggestions?

Dr. Bisplinghoff. No, sir. We proposed to OMB and OST that we hold such a review so as to be able to focus and bring together the total administration view in one place.

Mr. Tiernan. Was this the basis for these proposals? Were the changes made on the basis of that study in 1970 or was there another basis?

Dr. Paige. I believe that the 1970 Platt report gave a basis for change in the focus.

Dr. Bisplinghoff. We drew on a good deal of work by outside advisory committees and in fact we convened some outside advisory committees to help us with that internal review.[156]

Thus the whole story of OMB influence remained an enigma, even though OMB had definitely been an interested party in the restructuring of the education programs by Dr. Bisplinghoff's "Task Force" as just related in the testimony above.

But those Members of Congress who dealt with NSF did not appear to be swayed by the Foundation's arguments that the institutes were no longer useful, quite possibly because of the mail that a good many Members received from teachers and from a variety of organizations who wanted the institutes to be continued.[157] A year later the House Committee on Science and Technology would propose in its budget authorization bill, and in the associated report, that the NSF education programs be restructured to ensure that some of these programs would be on a sustaining, basis. The institutes, however, were not accorded this status.

Fl. The New Programs Create a Possibility for Difficulty.

Another issue, more sensitive than the possibility of OMB manipulation, would arise in the middle of the budget hearings for fiscal year 1976. It would be the result of the Education Directorate's, and perhaps the entire Foundation's, inattention to the very kinds of things Members of Congress had repeatedly warned against.

The events of fiscal year 1975 would not create the issue, but the restructuring of education programs in fiscal year 1974 and in previous years would produce a situation in which difficulty could—and did—occur.

Possibly the basis of the problem lay first with the Foundation's management by peer review and its reluctance to exert overt control over projects which it had funded, or to perform critical post-review of completed programs. Certainly the testimony of NSF officials, from Dr. Waterman, from Dr. Haworth and from others, had established that the Foundation had followed a policy of allowing the natural processes of self-criticism working within the education community and within the science community to decide the value of various projects. This was apparently as true in the area of curriculum development as in the area of science itself.

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[156] U.S. Congress. House. Subcommittee of the Committee on Appropriations. Hearings. 93rd Congress 2nd Session. HUD-Space-Science-veterans appropriations for 1975. U.S. Govt. Print. Off., Washington, D.C. 1974. p. 831 ff.

[157] See, for instance: U.S. Congress. House. Committee on Science and Technology. Subcommittee Science, Research, and Technology. The Science education programs of the National Science Foundation. Washington. U.S. Govt. Print. Off. 1975. 163 pp.

NSF was proud of its openminded scientific stance, and continued to make a strong case for allowing the community of scholars and experts to determine the value of the efforts supported by its grants. When questioned about how it provided for the wide diversity of preference among localities which might seek to adopt new science curricula, NSF answered that it attempted to sponsor a diversity of curricula on each important subject; but it did not tell the directors of a curriculum project how to treat thier subject. After all, they were the experts, not NSF.

Once a proposal for curriculum development had been reviewed by the peer process and was subsequently supported by a grant—and for a given proposal this review seems to have been generally performed at the discretion of a single NSF program officer without mandatory senior policy review—work was largely conducted without either ongoing supervision or review of curriculum contents by NSF officials. The test of success was whether the curriculum was adopted by educational institutions. Presumably under NSF's practice of developing a multiplicity of approaches wherever possible, educators could find a suitable choice of curriculum.

In any case, it was not NSF's original intent to develop the "last word" in curricula. Rather, it viewed its role as that of sponsoring pioneering efforts in curriculum revision, and in that regard the Foundation seems to have been very successful. Private publishers have copied, borrowed from, and imitated the majority of NSF curricula. This innovative role would seem to have been one of the Foundation's most important contributions.

On the other hand, the development of curricula in the social and life sciences opened the way for a great deal of difficulty. People often have strong feelings about ideas and concepts in these areas, and even about whether certain topics are suitable for discussion. As NSF moved from curriculum development in the mathematical and physical sciences into the areas of the life and social sciences, it was not sensitive to the fact that certain areas of knowledge, areas in which scientists deal every day and deem to be entirely acceptable for discussion, may be repugnant to some people.

Those who are thus offended may not favor allowing the Federal government to sponsor development of curricula which would include material that they consider objectionable. Congress had long recognized that hazard, and there were repeated instances of cautionary advice from Members of Congress on this subject in hearings records.

These warnings, however, were often paralleled by some degree of encouragement for NSF to become more heavily involved in areas that, in spite of their potential value, had a potential for attracting criticism. Similar encouragement has come on a number of occasions from within the Administration, in part from the President's Science Advisory Committee.[17a]

[17a] See, for example:

1. Strengthening the Behavioral Sciences. The Life Sciences Panel, President's Science Advisory Committee. The White House, Washington, D.C., April 20, 1962.

2. Innovation and Experiment in Education. The Panel on Educational Research and Development. President's Science Advisory Committee, Washington, D.C., U.S. Govt. Print. Off., March 1964.

Certainly the professional societies in the social sciences have given strong encouragement for greater NSF involvement in their area. But basic scientific research and curriculum development pose very different hazards, which NSF failed to guard against.

Curriculum implementation and distribution were comparable in sensitivity to curriculum development. As indicated repeatedly in the testimony, the dividing line between the reasonable use of NSF-supported curricula in summer institutes and Federal involvement in local school decisions may be hard to discern. When NSF found that educating teachers was to no avail if those teachers were forced to use inaccurate or outmoded curricula in their home schools, the Foundation mounted an extensive program of curriculum dissemination and implementation. But to some outside observers, such efforts would inevitably appear to be an attempt by the Federal government to promote the texts it had developed. In cases where those texts may be controversial, the situation has a serious potential.

Just as with curriculum development, there were strong and repeated warnings from Congress against the Foundation's becoming involved in situations which might appear to be influencing local curriculum decisions—but there was also encouragement that NSF take action to get its curricula into use, particularly in the early 1960's. It would seem that the congressional urging to do something to promote adoption of NSF's new science texts was evident for quite a number of years after Sputnik, and it was in those years that NSF developed its curriculum implementation policies.

By fiscal year 1975, curriculum development and implementation had become a strong focus of the new NSF programs. Part of the reason, as Dr. Stever had indicated in the budget hearings for fiscal year 1974, was OMB's reputed dislike for continuing efforts such as the summer institutes. So NSF had initiated new program objectives intended to meet many of the needs enunciated in the Platt Report in 1970, and other needs postulated by Dr. Bisplinghoff's "Task Force", but designed to do so within the guidelines of OMB.

F2. Congress Calls for a Review of the Education Programs

The NSF authorization hearings for Fiscal year 1975 in both the House and Senate tended to focus on issues other than education, though the sympathetic interest of the committees towards education was clear. However, with a relatively new Assistant Director for Education plus a brand new structure and set of operational objectives for the Directorate, the sentiment seemed to be to avoid asking questions prematurely. Thus there was very little discussion of education in the record for that year. Insofar as education was discussed, it was primarily to ascertain what the new program titles meant.

However, the lack of discussion in the authorization hearings did not indicate a lack of committee interest. The report accompanying the House authorization bill said the following:

> The Committee is concerned about the steady decline in the percentage of the NSF's budget which is devoted to Science Education. In 1970, 36 percent of the

> Foundation's budget was devoted to science education activities. In 1972 that percentage had gone down to 19 percent. In the proposed budget for fiscal year 1975 less than 10 percent would be devoted to science education activities. This year the Committee again found it necessary to restore funds to the budget for certain science education activities which the Committee in past years has strongly supported. As a result the percentage of science education funds has been raised to just under 12 percent, a figure still far below the percentage just a few years ago. In addition, while the Committee has supported the very substantial increase in science education research activities, there has clearly not been a continuation of support for the types of science education programs which constituted the bulk of the Foundation's science education program in previous years. In the Committee's view the balance between research and sustaining activities in the science education program must be redressed. The Committee invites the Foundation's attention to the strong interest in science education which is evidenced in the hearings on this subject, and as evidenced in the amendment to the NSF's organic act adopted by the Congress in 1972, specifically making the Foundation responsible for the Federal effort toward the health and growth of science education in the United States. A thorough review by the NSF of the long-range future of the science education program in light of these comments would appear to be in order.[158]

The Senate report addressed its attention in even broader terms:

> The Foundation requested $61.4 million for Science Education Improvement for fiscal year 1975. This is a reduction of $6.1 million below the legislative minimum established for this program in fiscal year 1974. However, the effective reduction of the program on a comparable basis with fiscal year 1974 is $11.1 million since $5.0 million of the fiscal year 1975 request represents a new effort for energy manpower resources.
>
> This decrease in science education support again reflects the imbalance in the Foundation's nonenergy support activities. To correct this imbalance, the committee has established a $71.0 million minimum for Science Education Improvement activities. The $8.6 million increase is based on the committee's belief that certain programs should receive special attention by the Foundation.
>
> The committee strongly urges the Foundation to expand its science education program for Ethnic Minorities and Women to a level of $8.1 million in fiscal year 1975. Ethnic Minorities and Women represent a relatively untapped science and technology manpower resource. The committee heard testimony from Mr. Miles Fisher, Executive Secretary, National Association for Equal Opportunity in Higher Education, in which he noted the serious decrease in the amount of funds requested for the minority college program at the same time the pool was being expanded to include minority institutions other than the historically black colleges. The committee concurs with the Foundation's action to insure that all minorities receive fair and equal treatment under this program. This expansion, however, will necessarily require an increased level of authorization and funding in fiscal year 1975. Therefore, the committee strongly recommends that $8.1 million of the Foundation's Science Education Improvement program for fiscal year 1975 be devoted to this purpose.
>
> The committee also urges the NSF to maintain strong support for programs designed to improve the quality and effectiveness of science teachers at the elementary and secondary school levels. The committee does not agree with the position taken by the Foundation that summer institutes aimed at upgrading the science subject-matter proficiency of teachers can now be phased out. Correspondence received by the committee indicates the opposite is true. Therefore, the Foundation should take the necessary steps to reestablish and maintain summer institutes specifically designed to enhance the subject matter competence of the teachers.

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[158] U.S. Congress. House. Committee on Science and Astronautics. Authorizing Appropriations to the National Science Foundation. Report together with additional views [to accompany H. R. 13999] Washington. U.S. Govt. Print. Off. 1974. H. Rept. 93-995. p. 128

> The Foundation's budget request for fiscal year 1975 discontinues the Faculty Fellowships Program which was funded at a level of $1.0 million in fiscal year 1974. Information provided the committee by outside witnesses and correspondence received by committee indicates that there is a clear need for a postdoctoral fellowship program. The committee recommends that the Foundation provide for a faculty fellowships program in fiscal year 1975 which is to be separate and apart from the proposed faculty research participation program.
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> The Nation's small colleges and junior colleges have contributed significantly to the development of high quality science and engineering manpower. It is estimated that as much as 40 to 45 percent of the graduate student enrollment in science and engineering is made up of students who have received all or part of their undergraduate training in small academic institutions. These institutions have an important role to play in science education and the committee urges the NSF to give these institutions careful consideration in implementing its science eduction programs in fiscal year 1975.
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> The committee has strongly endorsed the Foundation's program, designed to stimulate outstanding high school students to pursue careers in science and to provide opportunities for undergraduate students to participate in productive research. It has also encouraged NSF to maintain strong support for student originated studies. All these programs are scheduled for reductions in the programs presented to Congress. The recommended authorization which establishes minimum of $71.0 million for Science Education Improvement activities will insure that these programs and a range of these activities can be maintained at least at the fiscal year 1974 level.[159]

The resultant authorization act stipulated floors of $15 million for Graduate Student Support and $70 million for Science Education Improvement. Similarly, the appropriation stipulated that not more nor less than $13.2 million be spent on Graduate Student Support and not more nor less than $65,150,000 be spent for Science Education Improvement.

As of this writing, NSF has not issued its Annual Report for fiscal year 1975.

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[159] U.S. Congress. Senate. Committee on Labor and Public Welfare. National Science Foundation Authorization Act of 1975. Report [to accompany S. 3344] Washington, U.S. Govt. Print. Off. 1974. S. Rept. 93-838. p. 20, 21.

VI. CURRICULUM IMPLEMENTATION: NSF'S UNEXPECTED PROBLEM

A. THE FAILURE TO ANTICIPATE DIFFICULTY

As calendar year 1975 opened, the stage had long since been set for trouble. The Foundation had allowed itself to be enticed into a set of activities that, when combined, created just the sort of situation that quite a number of Members of Congress had warned against. As the issue emerged, NSF was totally, and apparently quite honestly, surprised at how its activities could be construed.

It would appear from the public record that neither the Foundation's senior administration nor the National Science Board had undertaken a detailed policy review of the entirety of the Foundation's education activities in some 20 years, and NSF seemed to have insufficient understanding of how seemingly innocent activities could couple with each other to produce serious problems. It had also come to overlook its carefully made agreements to limit its activities to dealing with individual teachers and to avoid dealing with schools.

It was not that the Foundation had entirely neglected to consider its practices and policies relating to education, for it clearly had made some effort. But NSF had apparently never seriously questioned the wisdom of allowing many of the most important decisions to be made by people outside of the Foundation, without some sort of careful examination of those decisions by responsible officers within the Foundation. Nor had it evidently appreciated that some of its activities, possibly generated under OMB pressure for greater emphasis on non-continuing education projects, could make it appear that the Foundation was directly involved in certain aspects of local school affairs.

Viewed individually from the NSF point of reference, the education programs were being soundly administered. The development of curricula was in the hands of the subject experts, who were encouraged to produce materials that reflected the latest findings and ideas of science. In NSF's view, it seemed inappropriate, and perhaps almost unthinkable, to review these curricula and possibly to eliminate material that science experts had elected to include. This seemed especially so for those curricula which had been physically structured in such a way that teachers and/or school systems could select which parts they wanted to present. After all, teachers and school officials were presumed competent to decide what material would be appropriate for their communities. But perhaps most important, the Foundation felt that revisions by NSF might constitute Federal curriculum control.

The Foundation also failed to recognize that parents would not necessarily know, at least with certainty, whether any particular part of a course had been deleted from the course being offered at their local school. In fact, most parents would reasonably assume that their local schools would make every effort to offer everything that was included in a particular curriculum. And to those who might be offended by some particular aspect of a curriculum, the Foundation failed to recognize that it might even be immaterial whether the offensive material was used in their own community. People with such concerns might well feel that the Federal government should have no hand in designing any curricula containing any material that seemed offensive.

The possibility of "poisoning the minds of a nation's youth" has always been an emotional issue. Even the great philosopher Socrates had to learn that fact in ancient Greece. To those who were offended, it apparently mattered little that others might feel that the new curricula constituted tremendous advances in education, or that such curricula might be both exciting to students and at the same time be scientifically accurate.

To NSF's consternation, the issue could not be "turned around" by citing all the impressive features of these curricula. But the issue might never have arisen had the Foundation maintained enough control of the curricula developed under its sponsorship to have been able to do some appropriate editing before release. The material which gave rise to public reaction was reported by NSF to comprise only a very small fraction of the curricula, so that most of it could probably have been eliminated, or presented in a more politic way, without substantive damage. But this sort of editing had apparently never been seriously considered by the Foundation, presumably because of NSF's concern about Federal influence in curricula.

Secondly, as indicated in Chapter V, the Foundation had begun a definite involvement with local school systems in improving both instruction and curriculum offerings. Prior to a few years before, the Foundation had essentially limited its efforts toward pre-college instructional improvements to dealing with individual teachers who became involved with NSF programs on their own initiative. Then the Cooperative College-School Science effort was begun in an effort to improve the effectiveness of local teacher-training and of the transfer of curricula to the schools. This seems to have been an effective, and reasonably non-controversial, beginning toward helping schools to work out their own problems. But the Foundation made a significant change in the level of its involvement when it began to escalate CCSS to focus on the implementation of curricula as an end in itself.

In going to a "project system," it was hard for NSF to avoid the appearance of becoming involved with specific tasks in certain schools and in certain school systems. Once the great teaching capability of the institute programs, and of other derivative programs of the institute effort, became focused on specific objectives of schools or of regions, the Foundation seemed to be on less secure ground.

Rather than dealing with individual teachers, the NSF was now dealing with the administration of community systems—albeit at the request of the administrators of those systems, but this offered little protection. Though the Foundation's new activities may have been the result of a series of logical responses to various problems, and though they may have seemed to NSF to be consistent with the Foundation's responsibilities, they were sufficient to raise concerns that the Federal government was imposing its ideas of what children should learn in local communities.

As in the case of curriculum development, the Foundation had not appreciated sufficiently the construction that outsiders might make of its activities, feeling that there could be no ultimate hazard in addressing what seemed to be a genuine National problem involving science education.

B. CONGRESS RESTRUCTURES NSF EDUCATION

The recent issue surrounding the Foundation's curriculum development and implementation programs did not materialize until late in fiscal year 1975. The budget authorization hearings in the House of Representatives proceeded smoothly, though the forthcoming committee report, which was not issued until after the trouble developed, was scheduled to contain some surprises for the Foundation in addition to its comments on curriculum problems. This report divided the Science Education Improvement activities into two parts: Science Education Innovation and Science Education Support. The ultimate Authorization Act (Public Law 94-86) retained this structure, which creates one program for innovation and another for sustaining programs. The committee report (H. Rept. No. 94-66)[160] indicated its intent as follows:

> The former science education category entitled "Science Education Improvement" was divided into two new line items entitled "Science Education Innovation" and "Science Education Support." This change was made to emphasize the Committee's strong conviction that both science education innovation activities as well as sustaining support for science education should be part of the NSF's science education program.[161]

It also recommended:

> An increase of $24.5 million in the Committee-proposed program of Science Education Innovation and Support. This program reflects the division of funds within the NSF program of Science Education Improvement into sustaining programs and research-oriented innovation programs for which NSF requested $17.2 million and $32.8 respectively. The recommended increase is based upon the Committee's conviction that science education should remain at a level commensurate with the increase in NSF's basic and applied research programs.[162]

Though the detailed program descriptions contained in the committee report were extracted from the NSF budget submission, their presentation in the new format tended to highlight new interrelationships between programs and new potential for several of the Foundation's efforts. The committee's presentation is therefore presented below to indicate both the nature of NSF's current education programs and as a statement of the intent of Congress for these programs in the immediate future:

SCIENCE EDUCATION INNOVATION

ALTERNATIVES IN HIGHER EDUCATION

> In the past, a major avenue for improving higher education in science has been the production of curriculum materials for use in a traditional lecture-recitation-laboratory format. Changing circumstances have shifted priorities towards newly emerging and problem-relevent subject areas, towards experimental or innovative educational strategies and mechanisms that can provide greater flexibility for matching the curriculum to the needs of the student and towards enhancing the effectiveness of higher education under conditions of growing economic stress.

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[160] U.S. Congress. House. Committee on Science and Technology. Authorizing appropriations to the National Science Foundation. U.S. Govt. Print. Off. 1975. House Report No. 94-66.
[161] Ibid, p. 137, 138.
[162] Ibid, p. 138.

Specific directions include:

Development of new materials and educational approaches, such as those with a modular format, in the areas of science, mathematics, and engineering.

Exploration of new and more effective ways of stimulating curriculum innovation and curriculum transfer.

Investigation of the relative cost of alternative approaches.

Experimentation with approaches that make education a continuing process following graduation from college or graduate school.

Offering of opportunities for students who wish to cross traditional disciplinary lines.

The overriding concern of all of these approaches is to provide greater flexibility in both undergraduate and graduate curricula so the student can receive an education that most closely matches the diversity of scientific needs of today's society.

The basic objective of the Alternatives in Higher Education Program in FY 1976 remains essentially the same as it was in FY 1975. Emphasis will be placed on development and testing of instructional materials and teaching strategies in science education designed to give greater flexibility and to provide the student with more options. Four separate but interconnected lines of activity will be used to carry out this program:

(1) development of institutional materials and modes;

(2) design and trial implementation of prototype alternative degree programs;

(3) prototypes for technician and technologist education programs; and

(4) partial support for instructional scientific equipment necessary for improved science instruction.

Development of instructional materials and modes

As in fiscal year 1975, major emphasis will be placed on the development of specific new course structures and materials. Although traditional disciplines are not excluded, higher priority will be given to projects that are interdisciplinary in nature, or that are intended to provide technical and scientific manpower in new areas where it is clearly needed. Projects already underway, plus others to be initiated in fiscal year 1976, will develop prototype modular materials in the basic science areas to provide the course materials for more flexible, non-traditional educational formats. Development projects with the potential of becoming self-supporting will be particularly encouraged.

In the past, a prime requirement for support under this program element has been potential national impact; proposals have been considered only when it could be shown that the benefits would extend far beyond the institution receiving the grant, and the burden of dissemination has been placed upon the grantee. As a result, many imaginative and worthwhile ideas have been discouraged because of their apparently local flavor. In fiscal year 1976, several relatively small but innovative projects will be funded wherein dissemination will not be the prime responsibility of the grantee, although possible national impact will remain a consideration.

In order to study the effectiveness of various means of dissemination of the resulting products of these projects as well as other newly developed materials and instructional programs, the Foundation this year plans to support experimentation in several differing forms of dissemination systems. Among these may be projects involving novel distribution methods of specific materials, publicity and information activities by scientific societies, etc. Ways of modifying, publicizing, and distributing materials originally prepared for a local market will be examined. The amount of $3,000,000 planned for fiscal year 1976 will fund about 35 projects.

Alternative degree programs

Following the Foundation's concern for providing more options for students of science and technology, support of alternatives to discipline-oriented degrees will be continued. These may include projects examining non-conventional elements in existing college-level programs such as internships. Emphasis on higher education programs in areas of societal need such as ocean engineering pest management and energy-related technology will be increased. A significant element of experimentation must be present, and the effort must be such that it could serve as a model to other institutions. The amount of $2,900,000 planned for fiscal year 1976 will support about 16 projects.

Science and engineering technician education program

The primary objective of this program component is the development, demonstration, and evaluation of a limited number of new or alternative programs that provide for the education of technical personnel to support scientific and engineering activities. Prototype programs based on existing science, engineering and mathematics materials will be encouraged which will provide an understanding of the scientific principles underlying a wide array of technical applications. Projects accommodating the development of both current and emerging technologies will be encouraged and attention will be given to areas of national concern such as those related to energy, the environment, and production technology. The amount of $1,700,000 planned for fiscal year 1976 will support about 10 projects.

SECONDARY SCHOOL SCIENCE CURRICULUM PROGRAM

This program element is directed toward providing secondary school students the best possible foundation for science or technology related careers. While not all persons entering careers in technology require baccalaureate degrees, all need appropriate skills in mathematics and science. Therefore, considerable flexibility in the preparation of high school students is required. Objectives of the program include:

(1) For students who will not go beyond high school, development of course materials attractive to a significant fraction of the enrollment is stressed which foster acquisition of problem-solving skills rather than provide training for specific jobs.

(2) For students who plan to go to college development of course materials which present alternatives to conventional discipline-oriented curricula, which are presented in flexible format appropriate for individualized study and deal with real world problems.

(3) Application of relevant, tested educational technologies to improve the educational process.

(4) Encouragement of activities to insure that the materials are well-known and properly used.

The program for fiscal year 1976 will center largely on the development of more timely and accurate teaching materials and more effective instructional strategies. Efforts will also focus on dissemination of information on these new materials to key decision makers in the schools and development of the leadership capacity for their adoption and proper use in the classroom.

Materials development, testing, and evaluation

As in fiscal year 1975, approximately $600,000 will provide for continuation of the development of projects focused on high school science and mathematics which are currently under way, including:

(1) Individual Science Instructional System—Developing new instructional programs, single- or inter-disciplinary, leading to a wider variety of scientific and technical career options for the individual student;

(2) Biomedical Interdisciplinary Curriculum Project—a curriculum for 11th and 12th grade students in preparation for careers in the health fields; and

(3) Four resource and teachers' centers to aid in dissemination and implementation of new mathematics and science materials.

An estimated $400,000 will be required for continuation of two newly initiated junior high level mathematics projects, providing alternatives to the current mathematics and aimed specifically at applications in mathematics to science and technology.

Instructional improvement implementation

To foster the effective use of new materials, about 25 projects will be supported to develop leadership for local implementation of the new course materials. Early in fiscal year 1976 new materials for the teaching of junior high school mathematics, the teacher preparation materials for the Individualized Science Instructional System Project, and units of the Biomedical Interdisciplinary Curriculum Project will be available for dissemination. This will require funding of $400,000 in fiscal year 1976.

SECONDARY SCHOOL SCIENCE LITERACY MATERIALS

The Secondary School program planned for fiscal year 1976 will continue to improve the substance and practice of science education for a broad range of students in junior and senior high schools. The two segments of this program, materials development and implementation, are very closely integrated. As new materials and methods are developed, tested and made available for dissemination and use in classrooms, the Foundation's plans, which were begun early in the development phase of the project to assist in their proper implementation, are put into effect. Among the principal objectives of this program component in fiscal year 1976 are:

(1) Development and testing of teaching materials and strategies.

(2) Assisting the dissemination of information about newly developed curricula to decisionmakers at the state and local levels.

(3) Assisting colleges and universities to participate with school systems in cooperative implementation projects.

(4) Broadening the base of individuals, other than curriculum developers, having skills needed in the implementation of specific materials.

The Secondary School Program element consists of two components: materials and methods development and the implementation of these improvements. The former provides support for development and evaluation of new course materials and teaching strategies, including continuing and new course development. The latter uses a variety of strategies to encourage dissemination of information about new courses and materials and their proper use in classrooms.

Development, testing and evaluation of teaching materials and methods

Approximately 75 percent of the funds will be required for continued support of ongoing projects including:

(1) Development of a modularized multidisciplinary high school science curriculum and related teacher training materials.

(2) Development of a sequential interdisciplinary human science course for the middle grades.

(3) Development of an interdisciplinary political science based curriculum.

(4) Development of materials and strategies for alternative (out of school) patterns of education.

New curriculum development and associated activities which will receive approximately 15 percent of the funds include:

A new junior high level mathematics course intended to enhance the understanding of the practical use of the subject by non-scientists and non-technicians. Although different in approach and degree of difficulty from existing courses, the new course will place more emphasis on applied mathematics including such topics as probability and statistics at an appropriate level.

Supplementary materials for use in existing courses on (1) energy-related topics and (2) recent findings on the structure and dynamics of the earth's surface.

The remaining funds will provide for problem assessment studies including evaluation of barriers to implementation and more precise data on usage of NSF-supported materials.

Funding requirements for the development, testing and evaluation of teaching materials and methods component of the secondary school science literacy program element will be $2,800,000 for fiscal year 1976.

Instructional improvement implementation

In support of implementation of course and curriculum materials whose development has proceeded beyond the testing phase, several kinds of activity will be employed:

Dissemination of information to school system decisionmakers about new and recently released curriculum projects;

Development of resource personnel among leaders with responsibility for initiating in-service education, to help install new and recently released materials broadly within a geographic area;

Orientation of influential teachers in new materials, who have verifiable responsibility to install them in their classrooms for demonstration and evaluation; and

Intensive implementation of new materials in a significant number of classrooms within a school system, through cooperative projects with nearby colleges or universities.

The foregoing activities are intended to offer a balance between widespread dissemination of a curriculum project and intensive implementation within selected school systems. The objectives are to obtain a large enough mass of successful usage to draw attention to the curriculum project; to set standards for quality implementation; to ascertain problems with materials after their release on a large scale which were not apparent during development; and to test the realism of usage goals for each curriculum project. Funding in the amount of $6,300,000 is planned for the implementation component in fiscal year 1976.

ELEMENTARY SCHOOL SCIENCE CURRICULUM PROGRAM

This program is designed to introduce into the school expertly developed and tested classroom activities which will stimulate the interest of elementary school students in science and mathematics. The two principal components of the program offer support for:

Development and testing of materials and instructional strategies which are attractive to young children, encourage learning, and increase their basic knowledge; and

Systematic implementation efforts to assure that materials which have been developed are used effectively in at least a limited number of classrooms.

Development, testing and evaluation of teaching materials

About 85 percent of the funds are planned for continuation of previously initiated projects which include:

An interdisciplinary (mathematics/science) problem-oriented course which requires active participation by students.

The two new mathematics projects initiated in fiscal year 1975.

Research in the learning of mathematics concepts and skills.

Studies of the impact of the newly developed curriculum materials in classroom situations and how these materials affect student learning.

Development of materials and strategies for alternative (out-of-school) patterns of education. The remainder of the funds will be required for impact studies of the usage levels of exisiting curricula and assessment of future curricular needs at this level.

Funding in the amount of $1,700,000 is planned for the teaching materials development, testing and evaluation component in fiscal year 1976.

Instructional improvement implementation

After curriculum materials have been tested and produced, they must be properly introduced into the educational system. This process of implementation includes:

Diffusion of information about new curricula and materials to decision-makers so that school officials are informed about what is available and appropriate for them to introduce into the schools;

Training of competent resource people in key positions within colleges, state education departments and local school systems to help schools identify their needs and organize efficient implementation activities.

The bulk of in-service implementation will have to be done under the auspices of local school systems since there are far too many elementary school classrooms for NSF to reach directly. The most appropriate role for NSF is: (1) to encourage the development of competent resource personnel; (2) to assist in the introduction of new materials in a sufficient number of situations having enough visibility to gain favorable attention; (3) simultaneously to develop models or standards for implementation activities.

Funding in the amount of $2,500,000 is planned in fiscal year 1976 for implementation activities in the elementary school science literacy area.

CONTINUING EDUCATION FOR SCIENTISTS AND ENGINEERS

As a result of the rapid advances taking place in science and technology, it has become increasingly difficult for scientists and engineers—whether in the college and university or in the industrial environment—to acquire current knowledge in areas that are not within their immediate professional concern. Unless effective and economical systems are developed for transferring newly developed information and approaches from the research laboratory to the potential user, is it likely that knowledge possessed by significant segments of the scientific-technical manpower force will suffer technological obsolescence, an obsolescence that will be socially and economically costly.

In the industrial sector, for example, such costs may manifest themselves in decreased productivity, a diminution in new product development and innovation, a poorer position *vis a vis* other high technology nations, and an inability to develop means for meeting societal problems in a rapid and practical manner. In the academic world, the consequences may include a mismatch between educational experience offered and skills needed in society, instruction that does not recognize the state of the science, and a general difficulty in utilizing improved methods as well as content of instruction.

To date, much of the continuing education available to nonacademic scientists and engineers has tended to take one of two forms: more or less conventional graduate or undergraduate courses offered by colleges and universities, or on-site highly specialized training courses offered by employers. One objective of this program is to develop processes of continuing education which fill the need for other types of training that will maintain career-long flexibility and vitality in industrial and governmental scientists.

If demographic factors, economic pressures, and past tenure practices at colleges and universities are examined, it becomes clear that these institutions now face (and will continue to face over the next 20 years or so) considerable difficulty in maintaining the vitality of their faculty. Thus, this program aims at developing mechanisms for insuring a base of strength in the specialized scientific areas in colleges and universities under conditions of limited resources and restrictions on new appointments. Very simply, the concern is to maintain the scientific vitality of faculty in higher education.

As in fiscal year 1975, important activities in this program will be the creation of means for identifying subject matter relevant to the continuing education needs of scientists and engineers, for producing the materials incorporating the necessary topical content, for delivering them cost-effectively to their intended audience, and for eliminating administrative and structural barriers to involvement. Two major objectives are:

To provide continuing education for nonacademic scientists and engineers, and

To maintain and improve the vitality of science faculty.

Continuing education for nonacademic scientists and engineers

High priority will be given to experimentation with:

New delivery systems that will allow educational information to be delivered quickly, accurately, and economically to the home or work site;

Professional society activities for maintaining and expanding the techincal competencies of their membership; and

Experiments with new approaches to industry/university cooperation.

Considerable latitude and flexibility in format and subject will be encouraged; projects which demonstrate educational effectiveness, widespread applicability, and potential for subsidy-free operation will receive a high priority. In addition, in fiscal year 1976 support will be provided for several small, but highly experimental projects, particularly those in areas of current national needs such as coal technology. The amount of $1,000,000 planned for fiscal year 1976, will support 5–6 projects.

EDUCATIONAL PROGRAM RESTRUCTURING

The goal of Educational Program Restructuring is to improve the effectiveness and efficiency of science education. To this end, the National Science Foundation will provide support to assist in the design, development and evaluation of a few major experimental models of new approaches to the organization, management, delivery and content of science education. Emphasis will be placed on design and development of projects whose outcomes can be evaluated and documented. The aim is the creation of generalizable and transportable models of proven usefulness. Experimentation with Education Program Restructuring will concentrate on three main areas:

Pre-service teacher education programs.

The undergraduate learning environment, and,

State, regional or urban systems of science education.

Unifying characteristics of experimentation in these areas of Educational Program Restructuring are a comprehensive approach to problems in science education in contrast to incremental approaches and, in every case, a concern for the ultimate cost of broad-scale implementation.

Grants will be made to colleges, universities, or other appropriate organizations and institutions for the following purposes:

(1) Restructuring of programs for the pre-service education of school teachers of science. Improved coordination of on-campus resources and faculties and coordination between colleges and schools will be fostered to provide models for the initial education of prospective science teachers. Mastery of subject matter and the development of competence in fostering learning, evidenced by the pre-service teacher's ability to produce or modify teaching materials, are expected objectives of such models.

(2) The creation of a limited set of dramatically different complete learning environments for undergraduate science studies. These new environments will be developed as extensive changes in existing institutional structures, or through the creation of new learning environments.

(3) Experimentation with models of new approaches to the coordination of efforts of schools, colleges, universities, State and local government, and private agencies in selecting a substantial specific objective as a target for educational reform, and developing and executing a coordinated plan for achieving it.

Experiments in pre-service education of teachers of science

Several prototype programs are now judged worthy of wide implementation. Consequently, effort will be channeled about equally into the development of new models and experimentation with modes of adaptation of already developed prototypes to meet local conditions. The fiscal year 1976 estimate of $1,500,000 should support the continuation of two projects, initiation of one new model, and the testing of 5 or 6 adaptation projects.

Experiments in restructuring the undergraduate learning environment

Opportunities will be provided for a limited number of colleges and universities to effect major comprehensive changes to produce significant and totally new approaches to the style, organization, and content of undergraduate science education. These new settings include those implied by such terms as "nontraditional students," "university without walls," "the learning laboratory," and "individualized," "self-paced," or "self-directed" study.

In addition to these large-scale restructuring experiments, a few relatively small (less than $20,000) awards will be made to individual faculty for highly focused restructuring of local science course content/or method of delivery. These projects will serve collectively as a feasibility study in dissemination of new research developments, and secondarily as a means to maintain faculty vitality. Funding of $2,000,000 is planned for fiscal year 1976 to support comprehensive restructuring projects.

Experiments in state, regional or urban systems of science education

The Foundation proposes to experiment with mechanisms for coordination of efforts to identify those mechanisms which will contribute most to strengthening science education. The approach will involve design and development of action programs and subject these to rigorous evaluation and documentation. The evaluated models are intended to provide examples for State and city utilization in order to make optimal use of local, State and Federal resources available for education. The proposed allocation of $1,000,000 will permit modest selective experiments of this type to continue.

TECHNOLOGICAL INNOVATION TO EDUCATION

The goals of the Technological Innovation in Education program are to improve the quality of education, to seek ways to slow its rising cost, and to enable faculty and students to understand and use computers and other advanced technological aids. Achievement of these goals requires the development and field-test of hardware, systems software, instructional concepts, curricular materials, and models for providing instruction in traditional and nontraditional settings. Support is therefore provided for:

(1) The development of computer and other technologies designed specifically for instruction;

(2) The development of promising technologically-based instructional concepts and materials;

(3) The field-testing and evaluation of prototype, technologically-based systems or models for education; and

(4) Mechanisms to facilitate widespread understanding and use of these concepts, techniques, and systems.

Support will be provided to continue the field tests of the PLATO and TICCIT computer assisted instruction systems and the computer based career guidance system called SIGI. Support will also be provided to prepare for a field-test of providing computer assisted instruction and other educational services in the home.

Experiments and field-studies will be initiated in order to explore the opportunities for using technologies such as PLATO within existing large-scale science curriculum development and implementation projects.

In addition, a set of pilot activities will be initiated to determine the value and cost of undertaking a nationwide program at the secondary-school level designed to provide an understanding of computer usage.

PROBLEM ASSESSMENT AND EXPERIMENTAL PROJECTS

The Foundation's activities for science education improvement are designed to act on selected key areas in the educational system where problems have been identified, are reasonably well defined, and where the infusion of relatively small amounts of money can significantly reduce or ameliorate problems, and improve the effectiveness and efficiency of educational operations.

It is clear, however, that there are additional problems for which solutions are not known—some for which suggested solutions have not yet been shown to be feasible, some for which potential solutions are still to be invented. And beyond these, there are problems, unidentified or only vaguely suspected, that must be identified so that the next step—the search for a solution—can be initiated.

It was in response to the need to identify and define these additional problems and to examine possible solutions that the Foundation's fourth science education improvement subactivity, Problem Assessment and Experimental Projects, was initiated in Fiscal Year 1974. The emphasis in fiscal year 1976 will continue to be on the search for effective solutions to problems and, as studies are completed, to their implications for the future direction of science education programs.

The basic objectives of the subactivity are to:

(a) Define and analyze problems in science education; (b) Study alternative explanations and possible root causes of the problems; (c) Formulate remedial strategies; (d) Assess the impacts and effects of remedies tested by other program elements of the Education Directorate; (e) Insure that the results of studies are fully reported and disseminated to appropriate policy and decision makers within the Foundation and the scientific and educational communities; and (f) Experiment with possible new approaches to problems in science education.

A special component within this program element concerns the Ethical and Human Value Implications of Science and Technology (EHVIST). Over the years the Foundation has supported these activities through various established programs in the Research, Applied Research, and Education Directorates. But because of its increasing importance, and based on the Foundation's experience accumulated through fiscal year 1974, a more systematic approach to the area was initiated in fiscal year 1975 and the Education Directorate was assigned the responsibility for coordinating activities, both within NSF and externally with the National Endowment for the Humanities and other agencies. This component will focus on the stimulation of scholarly activities in the area, and in keeping with basic NSF policy, projects concerned with establishing policy or regulations regarding ethical or other value issues will not be considered for support.

The program proposed for fiscal year 1976 is budgeted at $2,000,000 and will include:

(1) Continuation of support for 3 to 5 major problem assessment studies begun in fiscal year 1975 where significant gaps in the knowledge base have been found and which can be successfully narrowed with further study. In addition, a limited number of studies will be initiated which are designed to shed light on such problems as (a) the transfer of the results of experimentation with improvements in science education into common educational practice, (b) the proper and most effective role for the Foundation in providing science education to persons typically outside the formal educational system, and (c) effective modes of dissemination of information about new educational developments. Approximately $1,200,000 will be allocated to this aspect of the program.

(2) Establishment of a professional base in the Ethical and Human Value Implications of Science and Technology area by means of surveys, assessments of the present status of work in the area, and initiatives to stimulate, encourage, and facilitate communications and interactions among involved individuals and groups. Also supported will be basic research, curriculum development, conferences, colloquia, seminars and similar activities which will focus on such questions as (a) what values, if any, are implicit or explicit in the scientific enterprise? (b) how, if at all, is science/technology influenced by external value systems? (c) how, if at all, are external value systems affected by science/technology? Approximately $400,000 will be allocated to these projects.

(3) Analysis of the results of several studies and experimental projects designed to ascertain why such a small number of qualified women students and ethnic minority students choose to pursue careers in science. These projects were initiated in fiscal year 1974 and continued in fiscal year 1975; results will become available in fiscal year 1976. As knowledge is gained about barriers, further experimentation will be supported to test different mechanisms to increase the flow of ethnic minority and women students into science. This program component is budgeted at $400,000 in fiscal year 1976.

(4) Some of the more significant results of the first year of operation of the Ethical and Human Value Implications of Science and Technology (EHVIST) program in the Education Directorate are programmatic rather than project results. They include the preparation and dissemination of a a new detailed program description, improvement in the quality of proposals as a result of staff input and the formulation of explicit review criteria, and close liaison with the Science, Technology and Human Values Program of the National Endowment for the Humanities. Project results available by the end of fiscal year 1975 include the production and distribution of a comprehensive directory of EHVIST-related courses and curricula being offered at all 2-year and 4-year colleges and universities in the country, and several national conferences designed to stimulate and encourage interaction among individuals working in the EHVIST area.

The increase in funding in fiscal year 1976 primarily reflects the addition to this subactivity of the program component Ethical and Human Value Implications of Science and Technology and the transfer to this subactivity of studies relating to the barriers faced by ethnic minorities and women in science. In addition more attention will be devoted to assessing the impacts and effects of other program mechanisms within the Education Directorate.

SCIENCE EDUCATION SUPPORT

UNDERGRADUATE RESEARCH PARTICIPATION

When proposals will be considered in all disciplines, those proposals related to energy will have highest priority in disciplines in which energy-related investigations are possible. Funding in the amount of $3,000,000 planned for fiscal year 1976 will support 200 projects involving 1,350 undergraduate students in 160 colleges and universities.

STUDENT ORIGINATED STUDIES

Information gained through a formal study of this activity's impact and through project monitoring will be used in screening proposals for those with the greatest potential for achieving the stated objectives. Between 25 and 45 percent of the projects will produce reports that will cause communities to undertake further research, make policy decisions, or take action on societal problems studied in the project. (This prediction is based on performance in 1971, 1972, and 1973.) Funding at $1,000,000 will support about 70 projects involving some 650 undergraduate and graduate students from about 65 colleges and universities.

SECONDARY SCHOOL STUDENT SCIENCE PROJECTS

The Foundation will continue to supplement, wherever possible, local or regional resources and thus use Federal funds to extend to more students special opportunities for independent study in science. The amount of $2,500,000 planned for fiscal year 1976 will provide support for about 105 projects involving some 4,500 students from more than 3,500 high schools. Of this amount, an estimated $200,000 will be used to continue experimentation with a variety of projects designed to test ways to introduce project-centered instruction in the high school setting.

SCIENCE FACULTY FELLOWSHIPS

These fellowships are awarded to college teachers to enable them to spend 3 to 15 months temporarily freed from routine academic duties in order to strengthen their educational resources in ways that promise to make them better teachers. Activities may include actual course work, participation in group research projects, or studies leading to a master's or doctoral degree in new undergraduate-teaching oriented programs.

FACULTY RESEARCH PARTICIPATION

The objective of this program mechanism is to maintain the vitality of science faculty, and thereby their teaching, by involving them in research on problems of national interest and concern. Participation in appropriate research activities offered by industrial and government laboratories permits teachers to reevaluate the relevance of their course materials to the practical needs of our society. This "real-world" experience of the relationship between science and practical needs is to assist teachers in modifying course offerings to better prepare students to apply the results of their education after they leave the college or university.

During its first year, industrial and governmental laboratories have actively responded to the objectives of the program by providing opportunities for research on problems of energy conversion and storage, treatment of municipal and industrial waste products, marketing procedures, electronic communication services, food processing, and the production and new uses of metals and materials. Experience to date indicates that the program also has the advantage of providing an additional means of communication between university and industrial personnel—not only are the faculty exposed to unfamiliar applications of scientific information, but they often bring to these laboratories attitudes, methodologies, and knowledge unfamiliar to the industrial personnel. Further, personnel in both industry and the colleges and universities come face-to-face with the trained-manpower needs of industry and are able to evaluate the efficacy of college and university training in meeting those needs.

The fiscal year 1976 program will be directed to broadening the base of available research experiences by involving a wider range of industrial interests—wider in variety of scientific disciplines being applied and in type of societal problems being attacked, with particular reference to energy. The $1,300,000 planned in fiscal year 1976 for this program thrust will provide support for approximately 200 college and university teachers in about 90 projects at industrial and government laboratories.

COLLEGE FACULTY SHORT COURSES

One of the problems associated with efforts to maintain the vitality of faculty members, particularly in those two- and four-year colleges lacking on-going programs of research, is the time lag between the discovery of new knowledge by the basic research scientist and the publication of that information in scientific journals and textbooks. For several years the Foundation has been experimenting with short courses using the cost-effective "Chautauqua" format to make available to college teachers of science as quickly as possible new knowledge derived from the more significant current research topics, experimental techniques and instructional methods.

A special public lecture series on the future of science will be placed on the circuit to coincide with the Nation's bicentennial celebration. In addition, because of the cost-effectiveness of efficiency of this method of delivery of knowledge to teachers, experiments will be conducted to test the Chautauqua system as a method of delivering new developments in pre-college education to school teachers and administrators. The Foundation also plans continued experimentation with the use of workshops to enable college and university teachers capable of influencing the curricular offerings of their science departments to participate in testing, modifying, and adapting new course materials for implementation as a part of specific college or university curricular sequences. The amount planned for fiscal year 1976, $1,000,000, will provide for the participation of approximately 3,000 college faculty.

INSTRUCTIONAL SCIENTIFIC EQUIPMENT

Improvement of undergraduate education in science is achieved by incorporating new course materials and applying more effective and efficient instructional strategies in science curricula. Implementation of the improved courses frequently involves the use of instructional equipment. The Instructional Scientific Equipment Program assists in improving undergraduate science education by providing partial financial support for the purchase of the necessary scientific equipment. Grants are made on a matching fund basis by which the grantee provides at least 59 percent of the cost of the instructional equipment.

The increasing reliance of recent curricula practices on laboratory and data processing experiences as a more effective means of instruction has increased the need for instrumentation. Unless such equipment is available, undergraduate science education cannot accurately reflect current practice. New instructional equipment is required to provide for the implementation of the new student-oriented educational strategies, laboratory experience in mathematics, studies of the quality and control of the environment, analytical procedures in chemistry, data-gathering experiments in the social sciences, and studies of techniques of energy production and conservation. Requests for assistance in acquiring instructional equipment have now reached such a number that the program is currently able to support only about one-third of the proposals judged meritorious. The amount planned for fiscal year 1976, $3,000,000, will provide for approximately 360 awards.

ETHNIC MINORITIES IN SCIENCE PROGRAM

The objective of this program element is to increase the flow of ethnic minority group members into scientific careers through the mechanism of providing support for projects to improve institutions which primarily serve minorities. Such institutions are assisted in carrying out long-range improvements in their science education programs. Serving the needs of Black, Native American, and Spanish-speaking students, such projects may include activities such as upgrading of facilities, course and curriculum development and equipment acquisition.

During the fiscal year 1976 emphasis will be placed on the requirements of institutions whose students are predominantly Native American or Spanish-speaking, and those having a mixed minority student body. Though various ethnic minorities may often be subject to similar barriers and comparable cultural conditions, the means of enhancing the scientific potential of one ethnic group need not be the same as for another group; it is expected that experience during fiscal year 1975 will indicate the directions that support of the Native American and Spanish-speaking institutions should take in fiscal year 1976. The focus will continue to be on the enhancement of the scientific preparation of minority students; but, again, there may be special requirements occasioned by the circumstances of a mixed student body.

PUBLIC UNDERSTANDING OF SCIENCE PROGRAM

The Public Understanding of Science program seeks to increase citizen knowledge of the role of science and technology in society today. Continued national progress in scientific research depends to a significant extent on an informed and aware citizenry. The successful application of the results of this research in turn is affected by the understanding and involvement of decision makers who are not scientifically trained. Most of the pressing problems facing our society have significant scientific and technical underpinnings—energy, the economy, the environment, food, materials—and their solution will require an ever-increasing level of public sophistication in the selection of alternatives which are impacted by science and technology. Scientists are a key resource for informing the general public of the results and implications of their work in both basic and applied research.

Specific objectives of this program element are to:

Communicate to the public comprehensive information about the role, implications, potential, and limitations of science and technology.

Encourage scientists to assist in public understanding of science efforts.

Assist public groups and organizations in assessing the potential relevance of science and technology to their own interests and concerns.

The objectives are accomplished through the support of projects designed to communicate knowledge of science and technology to both the general populace and to such special publics as youth, minorities, rural populations, and others. Projects supported may include seminars and public forums relating science and technology to societal problems and needs, innovative film and television programs for lay audiences, museums exhibits or traveling demonstration programs on major themes of scientific investigation or societal problems related to science and technology, and special articles and publications for non-scientific audiences.

Another approach is to provide support for a small number of community and regional programs in public understanding of science serving mass or specific audiences in a discrete geographic area. Finally, special research projects are supported which measure the effectiveness of existing approaches to communicating science to the general public. Many of the projects supported receive "seed money" from NSF with other funds obtained by the recipient for follow-on or operational support.

Awards are made on the basis of peer review of unsolicited project proposals. Activities planned for fiscal year 1976 include:

Continued support for the national public television science series NOVA with particular emphasis on the development of a comprehensive national distribution system of the films and related educational materials for educational and other purposes.

Continued support for a variety of museum-related projects including cooperative programs between science museums, traveling exhibits and demonstrations on science and technology, and community education programs using museum resources and facilities.

Three community or regional communications programs to be supported involving public conferences, workshops, and other media dealing with science and technology-related interests and concerns of citizens. These programs will be modeled after previously supported programs in Tampa-St. Petersburg, Sonoma, California, and Honolulu.

COMPREHENSIVE ASSISTANCE TO UNDERGRADUATE SCIENCE EDUCATION (CAUSE) PROGRAM

The CAUSE program, initiated by the Committee for the coming fiscal year, will provide a means of strengthening undergraduate science education in the Nation's colleges. This program will provide specialized science teaching equipment, science teaching materials, and will allow the renovation of undergraduate science laboratories. It will afford opportunities for the implementation of new methods of teaching science developed elsewhere, and will permit departments and institutions to develop their own approaches to science teaching. CAUSE will also provide funds for the further training of science faculty and for the addition of new science faculty. Grants will be made on a competitive basis, and will be awarded to individual departments and institutions, to groups of such departments and institutions, and to undergraduate components of large universities. Interdisciplinary approaches to the teaching of science will be encouraged. Particular emphasis will be placed on encouraging the teaching of science in minority institutions and in two-year colleges.[163]

C. THE ISSUE GAINS POLITICAL FOCUS

C1. The MACOS Curriculum

Shortly after the authorization and appropriation hearings had ended, and before the respective reports had been released by the various committees, NSF came under strong and articulate criticism for the management of its pre-college education programs. Though discussion was initiated in fiscal year 1975, the impact would come to be upon the following year's activities. It would, at least in the short term, almost overwhelm the NSF Education Directorate.

The immediate focus of the issue was a social sciences curriculum, a good deal of it involving cultural anthropology, entitled *Man: A Course of Study* (MACOS). Intended to be used as a fifth grade curriculum, MACOS had been designed by Dr. Jerome S. Bruner, director of Harvard University's Center for Cognitive Studies. It attempted to address three questions that would seem to be fundamental to modern thinking in the field of social studies:

(1) What is human about human beings?
(2) How did they get that way?
(3) How can they be made more so?

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[163] Ibid. p. 101-116.

The course was developed by the same firm that had been established to market and publish the PSSC material: Educational Services, Inc. However, by now the firm had changed its name to Education Development Center, Inc. (EDC).

The curriculum was structured around 16 films to give students the immediacy of first-hand observation and to allow teachers to encourage students to use their own observational powers in learning. It also used a good deal of written material in the form of booklets.

Though there initially were considerable problems in trying to find a publisher, reputedly because of the multi-media nature of the course *and* its expense (initially about $3,000 per set), the MACOS curriculum is said at this writing to be in use in over 1,700 schools, with the State of California reported by NSF as having recently awarded certification of MACOS for use in its school system. In that sense MACOS has been a successful curriculum, though it has attracted community criticisms in a few school districts.

As with other innovative curricula, particularly those demanding new skills on the part of the teacher, MACOS requires careful and extensive teacher education. The same has been true of most modern science curricula, however, which was one reason why NSF was initially drawn into curriculum instruction. When poorly taught, these innovative courses have occasionally produced poor results and have therefore attracted parental criticism.

MACOS is said to place heavy demands on teachers, and to require extensive teacher training. Other curricula, such as SMSG—or "New Math"—have also attracted criticism in spite of their non-value-oriented subjects. Thus it may be that NSF is not choosing the best course in leaving curriculum development totally in the hands of science experts, who may not be fully cognizant of the problems faced by the *average* elementary or secondary teacher.

MACOS had the additional problem of subject matter. A large part of the course consisted of a study of the life habits, the culture, and the myths of a stone age society: the Netsilik eskimos. Movies showed how these eskimos have lived, hunted food, and survived in a very hostile environment. Pamphlets for the course told of their history and related some of their myths, thereby illustrating how the Netsilik culture was manifested. The culture of these primitive people (at least as portrayed in the course, since they have advanced significantly in recent years) reflected the harsh realities of survival under extreme conditions. Yet, according to those who praised MACOS, the underlying warmth and humanity of the eskimos is evident, and young students come to recognize that humanity and culture are distinct.[164]

One concept which MACOS purportedly attempted to teach was that a person's value as a human being could not be judged by his or her life-style. But important though this conclusion might seem to be to some people, it is a view that has the potential to offend some others and deserves to be introduced with care. While the use of the Netsilik eskimos was perhaps an effective method of presenting contrasts to students, it was probably not necessary to expose children to the full impact of a MACOS film showing in great detail the capture and slaughter of a seal, especially that part which showed children being given the seal's eyeballs to eat as delicacies. No matter that this slaughter was necessary for the survival of life, most people in the United States have never observed the grim process of an animal being slaughtered and these scenes were sanguine in detail.

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[164] For instance, see: Ferber, Ellen, What makes humans human? American Education. V6. No. 4; May 1970.

Certain people considered the subject of this film to be repugnant. Others were repelled by the eating of the seal's eyeballs. In addition, some of the eskimo tales and myths contained in the booklets of the MACOS curriculum described certain aspects of primitive religion and of the necessities of a primitive period of eskimo life which some people found very objectionable. These elicited a strong response from those who were offended or who felt that children's psychological balance or attitudes might be warped.

It might have been helpful to have had MACOS reviewed and possibly edited by a "Blue Ribbon Citizen's Panel" for acceptability, in order to counter some understandable parental reaction to certain behavioral patterns which Eskimos once practiced to survive. Though NSF could question the effects on society of avoiding discussion of "delicate" material at the pre-college level, equal questions were to be raised about the effect of such material on children's minds.

C2. Some Differences of Opinion

The divisions of opinion expressed about MACOS were sharp. The scientists and NSF seemed to feel that they had created a valuable instructional experience for children. To their minds, the course was a great success in conveying difficult and subtle concepts about human behavior to children in a way that allowed them to observe events and to draw their own individual conclusions out of class discussion. To the scientists who were involved, this seemed to be the best way to increase the awareness of students about cultural problems: apparently much preferable to stating lists of rules or establishing complicated criteria of what is, or is not, the actual basis for proper human interaction in a society.

The reaction of a great many teachers and students using MACOS was also strongly favorable. And the MACOS course was presumably, within its interdisciplinary area, scientifically sound. From the Foundation's standpoint it was therefore a great advance over former attempts to treat the subject. And in comparison to PSSC, which had cost roughly an equal amount to produce a decade earlier, MACOS had been inexpensive to develop by comparison.

Elementary school systems seem to have been attracted to this course for a variety of reasons. In the opinion of some educators, it is an interesting subject with an interesting approach. Many of those who use MACOS feel that it draws upon the creativity of children to generalize on their observations and to make their own conclusions. Some feel that it fits very well into certain modern structural formats, such as the *open school*. It probably relieves some teachers of the boredom of teaching rote courses, and seems to provide excitement to students in a subject that can be very difficult.

Those who like MACOS say that children of a wide range of intelligence and background find the curriculum of definite interest, probably much more so than standard texts. However the course materials are very expensive, about $3,500 minimum per copy in 1975, and teachers require careful instruction to present the material effectively.

On the other hand, there are undoubtedly some teachers who are more successful with more structured classroom situations, who might find MACOS a great source of difficulty because the students play such a great part in teaching themselves through teacher-led group discussions.

The reaction of parents seems mixed: with many very strong proponents and equally strong critics. In his examination of the subject, Senator Kennedy obtained strong endorsement *and* strong objections to MACOS from parents, educators, and others with professional experience on topics relating to the question of whether the course is appropriate for children.[165] It would be beyond the intent of this study to provide a detailed analysis of MACOS, but suffice it to say that substantive questions were raised in hearings by witnesses, including two congressmen.

While this study is not intended to adjudicate this area of disagreement, other matters deserve comment. One is that of taste and the judicious selection of material in NSF-developed courses, which are intended to be widely disseminated. It would seem that in this area the judgement of academic scientists, however eminent, might well have been augmented by considerations of general acceptability at the pre-college level. Another question is whether NSF has been following the most judicious course in its implementation and curriculum publication procedures. Here there would seem to have been the possibility of Federal interference in the local schools and of undue subsidies to Federally sponsored curricula.

C3. NSF Studies its Programs.

These problems were carefully reviewed by NSF and the conclusions were communicated in an unusually candid report [166] which is reprinted in Appendix F. It would appear from the report that the Foundation managed to uncover many of the problems that produced the current situation. The report recognized the need for review of developed curricula before public release and mentioned a number of other important matters.

However, it still stressed major reliance on outside panels and reviews, when it would seem that one important question arising from the current problems was whether NSF needed to establish some internal review capability. As shown by a number of examples related earlier in this report, there have been occasions when NSF advisory committees and panels have not been of significant help in developing new policies or in helping NSF to avoid unanticipated difficulties.

Outside panels and reviewers seem to have performed adequately in most cases when the criteria for judgement and the objectives are able to be clearly stated, but they have not seemed as useful in maintaining effective management when issues have been vague or unspecified. There is good reason to ask whether it is appropriate to expect outside volunteers to ferret out unsuspected problems associated with new curricula, or to adjudicate between questions of public acceptability and taste as opposed to the presumed need for scientific completeness of a curriculum. In addition, good detailed advice on extensive matters such as curricula would seem to require months of study and effort, and therefore to place excessive demands on outside reviewers. This, plus the difficulty of delegating actual responsibility for curriculum content, would seem to require that final decisions on curricula be internal to NSF. In this sense, the Foundation's report failed to deal with the most important elements of the problem of how to administer the curriculum development programs.

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[165] U.S. Congress. Senate. Committee on Labor and Public Welfare. Special Subcommittee on the National Science Foundations. Hearings, 94th Congress 1st session. National Science Foundation Legislation, 1975. Washington, U.S. Govt. Print. Office. 1975.

[166] National Science Foundation. Pre-College Science Curriculum Activities of the National Science Foundation. Report of the Science Curriculum Review Team. May 1975 Volume 1—Findings and Recommendations.

D. THE 1976 AUTHORIZATION AND APPROPRIATION

The appearance of the MACOS issue seemed to delay the issuance of the NSF authorization report by the House Committee on Science and Technology. Then, shortly after the report (H. Rept. 94–66) was issued on March 20, 1975, it was withdrawn while the committee met to decide whether the MACOS issue merited some sort of changes in the report. The committee elected not to change the report (which reappeared as House Report 94–99), apparently by feeling that the following statement provided a sufficient indication that the issue was serious and was to receive careful scrutiny:

> The Committee gave consideration to the National Science Foundation's policy regarding the implementation and distribution of science curriculum materials developed under NSF grants. In past years the Committee has urged the NSF to insure that such curriculum development activities do not result in the development of useful and relevant materials which, however, are not then put into use in the classroom. The Committee therefore, in the past specifically asked the Foundation to undertake implementation activities which would insure that information about these curriculum materials, their nature, and their availability became known to the educational community. In addition, where needed, the NSF was asked to provide assistance in the actual implementation, on a selective basis, to school systems which on their own choose to adopt these materials for classroom use.
>
> This year it has been brought to the Committee's attention that in some cases the NSF has gone somewhat beyond its normal implementation stage with activities which appear to involve the marketing of curriculum materials. In one specific case involving the anthropology course offered, "Man: A Course of Study" the Committee received a number of indications that the dissemination of the course was being achieved through a form of subsidization which places it in competition with similar course materials developed and/or distributed by private enterprise.
>
> Accordingly, the Committee requests that the NSF defer further funding of implementation activities for this particular course, pending a thorough review of the Foundation's overall curriculum implementation policy, as well as this particular example of it. The Chairman of the Committee will appoint a small, impartial review group to study this question and submit to the Committee a report no later than May 31st. This review group will include representatives of those involved in the implementation of curriculum materials, those in the private sector engaged in this field, and the staff of the National Science Foundation.[167]

At the time of this writing the results of this study under the committee's direction have not been reported.

But this congressional review was not sufficient to allay congressional concern. Various amendments were offered to the authorization bill during the House debate attempting to limit NSF's authority to make grants.[168] The curriculum issue was intertwined with other issues which are too extensive to detail in full here, and whose influence is uncertain. However, at least one other major factor affecting congressional opinion was the Foundation's continuing use of research grant titles that, to nonscientists, appeared frivolous. Since grant titles have always been matters of public record, and have been widely distributed in many NSF documents, some of those titles which did not well reflect the serious intent of the associated research have come to attract public attention. This was, of course, a problem which has arisen in many of those agencies making grants and contracts, for the public has always been attentive when it has felt that its tax money has not been well spent.

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[167] H. Rept. 94–66 p. 144, 145.

[168] Authorizing appropriations to the National Science Foundations, [Debate and vote in the House] Congressional Record, V121, April 9, 1975 Daily Edition H2575–H2607 incl.

In July 1974 the General Accounting Office had released a list of 35 grants and contracts whose titles had been recently cited in this regard. They included 14 offices of the Federal Government. The National Science Foundation was not predominant on the list: it had only two grants, the most recent of which had been made in 1964. However, over the years a number of Members of Congress had apparently received a good deal of mail about questionable titles of NSF grants. Even some Members who supported the Foundation seemed to feel that NSF should have taken steps to eliminate this problem long ago.

Problems with public concern over NSF grant titles extended back as far as the 1950's, and have been almost a perennial matter for discussion in NSF's appropriation and authorization hearings. Yet NSF never took the trouble to rewrite the titles which scientists put on their grant proposals, and with few exceptions those titles became the titles of the ultimate grants. In spite of the fact that the Foundation had supplied information showing the serious intent of grants following congressional inquiry about titles, Members of Congress had often commented on their personal embarrassment over these public inquiries about possible NSF mismanagement.

It would seem that this long-standing issue may have added to an impression in Congress that NSF management was either very weak or was insensitive to public reaction. In either case, it probably raised a further question in some minds. When the NSF authorization bill (H.R. 4723) came to be debated on the floor of the House on April 19, 1975.[169] Mr. Conlan of Arizona offered the following words in an amendment:

> Page 7, immediately after line 12, insert the following new subsection:
>
> (b)(1) No funds authorized to be appropriated to the National Science Foundation under this or any other Act shall be available to implement or market course or curriculum programs or materials unless the Committee on Science and Technology of the House of Representatives and the Committee on Labor and Public Welfare of the Senate have first been provided a complete prospectus for each course or curriculum project proposed for such finding by the Foundation, and—
>
> (A) the funding to implement or market such course or curriculum programs or materials has been specifically approved in an Appropriation Act; or
>
> (B) both Houses of Congress have adopted a resolution approving such funding for implementation or marketing.
>
> (2) For purposes of this section, a prospectus shall include—
>
> (A) the grant application with names and institutional affiliation of applicants, justification for the implementation grant, and duration of the project;
>
> (B) a complete description, educational objectives, and historical overview of the course or curriculum to be implemented;

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[169] Authorizing appropriations to the National Science Foundation, [Debate and vote in House] Congressional Record, V121, April 9, 1975 H3575–H2607 incl.

(C) copies of all evaluations and recommendations concerning the implementation proposal; and

(D) the National Science Foundation budget and fiscal report, the total per-pupil cost to implement the course or curriculum, sources or other funding, and a projection of future Federal funding for the course or curriculum.

The amendment was defeated by a fairly narrow margin: 196 for, 215 against. Then Mr. Myers of Pennsylvania offered these words in an amendment.

> No funds authorized to be appropriated to the National Science Foundation under this or any other Act shall be available to implement any course, curriculum, program, or materials in a public primary or secondary school, unless the National Science Foundation, the grant recipient, or the school board of the community involved shall first give public notice to the local community concerning the contemplated introduction of said course, curriculum, program, or materials into a particular school or school system prior to its introduction; and second, all teaching materials used in the training of teachers for the program and the instruction of the program's students shall be made available for public inspection.
>
> Such public notice shall occur a reasonable time before the introduction of the course, curriculum, program, or materials and in no case less than 60 days; the teaching materials shall be available for public inspection at a school within the public school district during the period of public notice and shall continue to be available at the school for inspection throughout the duration of the course, curriculum, program, or materials' period of use in the community's schools.

This too was defeated, but by a larger margin: 68 for, 341 against.

D1. The Bauman Amendment

Then Mr. Bauman of Maryland offered a much broader amendment:

> Amendment offered by Mr. Bauman: On page 7 beginning with line 12, strike out all through line 18 on page 7 and insert in lieu thereof the following new section:
>
> "SEC. 7. (a) Notwithstanding any other provision of this or any other Act, every 30 days the Director of the National Science Foundation shall transmit to both Houses of Congress a message containing:
>
> "(1) A list of grants, proposed to be made by the National Science Foundation and,
>
> "(2) All facts, circumstances, and considerations relating to or bearing upon the decision of the National Science Foundation to approve said grants, including to the maximum extent practicable the manner in which the national interest will be fostered by the approval of such grants.
>
> "(b) The grants transmitted under subsection (a) of this section shall be effective at the end of the first period of 30 calendar days of continuous session of Congress after the date on which the message is transmitted to it unless, between the dates of transmittal and the end of the 30 day period, either House passes a resolution stating in substance that the House does not approve all or any number of the grants listed therein."

This passed, 212 for, 199 against. Adoption of this amendment seemed to be a clear indication of congressional concern that something was amiss. It would seem to have been a clear call for some substantive changes by the Foundation aimed at strengthening its authority and management in areas of public sensitivity.

In consequence of these events in the House, on April 21 Senator Kennedy reconvened his Special Subcommittee on the National Science Foundation, which had essentially completed its authorization hearings on March 14, for an additional day of hearings to specifically focus on the education and MACOS issues. The Committee on Labor and Public Welfare subsequently reported a separate bill (S. 1539) which did not include Mr. Bauman's amendment, but the committee report [170] on the bill took a strong stand on a slightly different matter:

> Notwithstanding current controversies, this Committee does not seek to pass on the merits of any specific NSF effort to develop or implement science curricula at the elementary level. It does, however, very strongly disapprove of any attempt by NSF to subsidize the marketing or promotion of such curricula. The Committee wishes to make clear that it does not intend that any NSF developed curricula be rendered a competitive advantage over curricula developed by the private sector. NSF may properly disseminate information with respect to curricula and their availability to local school districts, but it should not attempt to in any way influence local districts as to the choice of such curricula.

The Bauman Amendment was eliminated in conference between the two Houses,[171] but the warning to NSF was clear. As if to confirm its interest, the House Committee on Science and Technology soon undertook to examine a number of other factors in the management of NSF. The system of peer review was among the first topics, and it seemed that by the end of the Fiscal Year 1976 a fairly exhaustive oversight examination would have been accomplished.

D2. The National Science Board Issues Three Policy Statements

On June 20, the National Science Board adopted three policy resolutions relating to the operation of NSF's education activities. They had been prompted by NSF's earlier review of its pre-college curriculum activities [172] and were stated as follows:

1. POLICY STATEMENT ADOPTED BY THE NATIONAL SCIENCE BOARD AT ITS 174TH MEETING ON JUNE 20, 1975, ON PLURALISM IN EDUCATION

> The National Science Board recognizes that much educational innovation is, by its nature, controversial. It therefore follows that, if the educational mandate of the National Science Foundation is to be carried out, the Foundation cannot, and should not attempt to, avoid controversy in the development and implementation of new materials. The Board notes that:
>
> 1. The United States is deeply committed to pluralism in education.
> 2. The National Science Foundation, in order to strengthen science education at all levels, has supported the development of science course materials for use in the schools. The Foundation is further committed to assisting those with final responsibility for selection of course materials by creating conditions allowing choices to be made among scientifically sound alternatives through widespread dissemination activities and to assist in implementing those choices.
>
> As a consequence of this pluralistic value system the Foundation should disseminate as many alternatives as are feasible and necessary given the diversity of views and needs.
>
> To ensure that Federal funds do not directly or inadvertenly lead to the development of a monolithic curriculum structure, and to ensure the diversity that society requires, the following procedures are recommended.
>
> 1. The National Science Foundation should carry out a broad-based analysis of future needs in subject areas and publicize such needs.
> 2. The Foundation should ensure competitive selection of project developers addressing these needs.
> 3. It should encourage development of alternatives by NSF.
> 4. The Foundation should establish administrative procedures in the implementation stage that will avoid any appearance of indoctrination or coercion.

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[170] U.S. Congress. Senate. Committee on Labor & Public Welfare. The National Science Foundation Authorization Act, 1976. Washington. U.S. Govt. Print. Off. 1975. Senate Report No. 94–111, to accompany S 1539.

[171] U.S. Congress. House. Committee of Conference. Conference Report to accompany H.R. 4723. Washington, U.S. Govt. Print. Off. 1975. House Rept. No 94–422. See also: Providing for consideration of converence report on H.R. 4723, National Science Foundation Authorization Act, 1976. Congressional Record, v. 121, August 1, 1975. Daily Edition H8063 ff.

[172] National Science Foundation pre-college science curriculum activities. op. cit. Reprinted in Appendix F.

2. POLICY STATEMENT ADOPTED BY THE NATIONAL SCIENCE BOARD AT ITS 174TH MEETING ON JUNE 20, 1975, ON CURRICULUM DEVELOPMENT ACTIVITIES OF THE NATIONAL SCIENCE FOUNDATION

For 20 years the National Science Foundation has been, with the support of the Administration and the Congress, a leading instrument for improvement and strengthening of school science curricula and of school science teaching. When NSF came on the scene science teaching materials and practices were often uninspiring and outdated. At the same time, world society and American conditions were changing in a fashion which required a population better educated in science. NSF programs for the improvement of course materials in biology, chemistry, earth sciences, mathematics, physics, and social sciences have provided important examples to meet this objective. Compared to the total financial resources of the school operation, the NSF effort has been small but it has brought together scientists and educators in an effective manner to provide the needed new science materials and institutional practices.

The statutes defining the responsibilities of the National Science Foundation are explicit in directing the Foundation to strengthen science education at all levels. The strength of science education throughout the Nation depends in no small way upon the quality and character of course materials and instructional practices available to the individual teacher.

The National Science Foundation has a continuing role in the development of course materials and teaching methods in the mathematical, physical, medical, biological, engineering, social, and other sciences at the pre-college level. The Foundation can and should make a unique contribution by bringing new, intellectually challenging science content and teaching methods to elementary and secondary school students and their teachers. The program should be broadly aimed at encouraging future scientists and technologists as well as increasing the quality of science education available to all students at the pre-college level.

3. POLICY STATEMENT ADOPTED BY THE NATIONAL SCIENCE BOARD AT ITS 174TH MEETING ON JUNE 20, 1975, ON NSF IMPLEMENTATION OF SCIENCE CURRICULA

State and local authorities have final responsibility for the selection and adoption of educational materials and practices. Ideally such selection is based upon adequate information about available alternatives. The National Science Board therefore affirms a continuing role for the National Science Foundation (NSF) in supporting activities designed to disseminate widely information about available alternatives and to assist members of the educational community in the use of new, innovative, and scientifically sound materials and practices in which they have demonstrated an interest.

Prior to undertaking full-scale dissemination and assistance activities for NSF-developed materials, NSF should undertake a careful review to ensure that the proposed subject matter fits within reasonable limits or norms with respect to educational value and that the scientific content is accurate. Recognizing the broad base of concern with elementary and secondary education, the Foundation should provide opportunities for input in this review by representatives of the scientific, educational, child development, commercial publishing, and informed public communities.[173]

Though these statements represented the Foundation's position quite well, they did not seem responsive to some of the realities of the issue.

D3. I[illegible]ementation Funds Eliminated for FY 1976

On [illegible]ne 19, the House Committee on Appropriations reported out H.R. 8070, which included appropriation recommendations for NSF. The provisions of this report[174] were severe: there would be no funds for curriculum implementation in fiscal year 1976. The discussion made clear the committee's continuing serious intent in considering this problem:

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[173] Press Release, National Science Foundation, June 23, 1975, NSB issues policy statements to strengthen science education NSFPR75-60.

[174] U.S. Congress. House. Committee on Appropriations. Department of Housing and Urban Development—Independent Agencies Appropriation Bill, 1976. Report together with Minority and Dissenting Views to accompany H.R. 8070. Washington, U.S. Govt. Print. Off., 1975, House Report No. 94-313.

> *Science Education.*—In recent years science education support has been substantially downgraded by the Foundation and the Administration. The Committee is greatly concerned about the extent to which the National Science Foundation has supported the promotion and marketing of course curriculum for elementary and secondary schools and the concentration of these activities on courses that have been developed with NSF or other federal support. The Committee recognizes the need to acquaint teachers with new course materials but federal support for activities designed to get high school and elementary school administrators, members of school boards and other curriculum decision makers to adopt curricula developed with Federal funds could lead to the establishment of a single federal standard for education in the various fields of science.
>
> It is significant that one social science course for 5th graders entitled "MAN: A Course of Study" which has stirred considerable controversy because of its value orientation which many parents feel runs counter to western cultural standards has already been implemented in 1,700 schools nationwide. NSF recently funded a grant to the developers of MACOS which announced plans for the further spread of these studies. Regardless of the merits of a particular course of study, the Committee believes that the provision of federal funding for unique education marketing activities tends to give particular courses unfair advantage in the market place and therefore it is of extreme importance that federal intervention in the development of curriculum, and especially in its implementation be fully justified on a course-by-course basis to the Congress and to a broad base of public, educator, and professional organizations and parent groups nationwide.
>
> The Committee is chiefly concerned about courses which are value oriented and which fall in the broad behavioral science category. This includes MAN: A Course of Study, Exploring Human Nature and other courses dealing with political attitudes and moral values. Since the Foundation is currently developing a number of courses in these areas and is in the process of implementing others which have never been reviewed by the Committee in terms of their national need, the Committee has included no funds for the implementation of courses in 1976. This will give the Foundation time to prepare the necessary data and to fully inform the Congress and the public of its intentions and the basis on which it has determined the pressing national need for such course material. It will also give the Congress time to fully evaluate the impact of federal involvement in this field and arrive at effective public policy guidelines for the development and implementation of such materials. This means that no funds are appropriated for implementing courses that were budgeted in the line items for "Instructional Improvement Implementation" in the elementary and secondary school programs.
>
> The authorizing committees are currently reviewing the education program structure in some detail and allocations of funds are still pending. The Committee recommends total new funds of $60,000,000 for science education activities. This may be supplemented with from $4,000,000 to $9,500,000 of deferred funds from 1975, and the reapplication of the $9,200,000 denied for Instructional Improvement Implementation. The proportionate allocation of such funds, in general conformance with the authorization that may be provided for such programs, is contained in the language of the bill. This proportionate allocation is expected to be applied to elements within programs based upon appropriation availability to the program in the same way the proportionate allocation to programs is applied based upon total availability.
>
> A limitation providing not more than $1,000,000 for a program of Ethical and Human Value Implications is included under the Science Education program. This provides a substantial increase for next year.[175]

It also mentioned the problem of research grant titles:

> In recent months particular activities of the Foundation have been questioned. Members of Congress, representatives of the press, and countless American taxpayers have been openly critical of the use of tax revenues to finance seemingly frivolous and irrelevant scientific research projects. A number of specific examples have been cited, and responsibility for some has been attributed to the Foundation. Investigation has shown that in *most* cases the responsibility for these grants rests with agencies other than NSF, and some charges of frivolity have stemmed from and inadequate understanding of the scope, purpose and intent of the research.[176]

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[175] Ibid. p. 35, 36.
[176] Ibid. p. 33.

On June 24, the House favorably voted the bill after fairly lengthy debate relating to these two problems.[177]

On July 24, the Senate Committee on Appropriations reported on the House bill.[178] The section on NSF contained an extensive introduction:

> The National Science Foundation is the principal Federal basic research agency concerned with insuring that the United States maintains a strong and productive scientific research program. NSF supports basic and applied research projects initiated by scientists throughout the country and at present is funding more than 18,000 projects. The selection, monitoring and evaluation of these projects are the central daily tasks of the National Science Foundation staff.
>
> The programs of the National Science Foundation are designed to meet the responsibilities assigned to NSF by the National Science Foundation Act of 1950 as amended and Title IX of the National Defense Education Act. The National Science Foundation's programs as authorized by these laws:
>
> Strengthen U.S. scientific research in the mathematical, physical, medical, engineering, biological, social and other sciences.
>
> Focus an appropriate fraction of U.S. science resources on selected current national problems.
>
> Strengthen science education programs at all levels.
>
> Stimulate international scientific cooperation between U.S. and foreign scientists.
>
> Assist in providing the Nation with highly trained scientists and engineers through a program of fellowships for science and engineering.
>
> Establish a Science Information Service and make science information more readily available to U.S. scientists and engineers.
>
> Appraise the impact of research upon industrial development and the general welfare.
>
> Gather and publish scientific and technical data pertinent to national science policy decisionmaking.
>
> The Committee continues to be concerned over the Foundation's tendency to fund what seems to be low-priority research in the social sciences, and, equally important, its failure to be more responsive in explaining its program to the average American taxpayer.
>
> The Committee acknowledges that the National Science Foundation has studied the social science program internally through the use of a staff group on social science research and through the Director's Program Reviews. At the same time, the National Science Board has established a subcommittee to examine social science programs and the NSF Advisory Committee for Research has formed a social sciences task group to evaluate the successes and failures in this discipline. Although these in-house studies are useful "first steps," the Committee is more encouraged by NSF's recent decision to contract with an outside agency—the National Academy of Sciences—to conduct an indept study of the National Science Foundation's social science programs. The Committee hopes an objective analysis of the problems associated with the social science research programs will complement the NSF staff and committee studies and pave the way toward improving both the basic and applied social science research effort at NSF.
>
> Although the Committee does not recommend granting Congress veto authority over individual research projects, it does feel that NSF's lack of concern for public understanding of scientific research is detrimental to the average American taxpayer who wants to know how his money is being spent. The Committee does not feel that the Congress should pass judgment on every project title, but the academic and scientific communities have an obligation to the layman to be able to communicate, in plain, simple English what their objectives are, what they hope to find out, and what the potential benefits could be to the "man on the street." The Committee, therefore, feels that it is up to the National Science Foundation to demand this degree of responsiveness from its grantees and increase its effort in explaining to the taxpayers how their hard-earned dollars are being invested in scientific research.

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[177] Providing for Consideration of H.R. 8070. Department of Housing and Urban Development—Independent Agencies Appropriation Bill. 1976. Congressional Record. v 121, June 24, 1975, daily edition H6001 ff.

[178] U.S. Congress. Senate. Committee on Appropriations. Department of Housing and Urban Development—Independent Agencies Appropriation bill, 1976. Report to accompany H.R. 8070. Washington. U.S. Govt. Print. Off. 1975. Senate Report No. 94-326.

> Along these same lines, several Members of Congress on both sides of the Capitol have expressed their concern over the "closed door policy" of NSF's peer review system. The Committee can understand the well-intended desires of these Members to "open" the grant review system and let the public and principal investigators know who is reviewing the proposals and what comments those reviews contain. However, the Committee feels that the Foundation has taken a significant step in resolving the controversy between advocates of "openness" and defenders of "confidentiality." On June 20, 1975, the National Science Board resolved that:
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> 1. The Foundation will publish annually a list of all reviewers used by each Division.
> 2. Program officers should seek broadly representative participation of qualified individuals as reviewers.
> 3. Verbatim copies of reviews requested by the Foundation after January 1, 1976, not including the identity of the reviewer, will be made available to the principal investigator/project director upon request. The question of including the identity of the reviewer will be considered further by the National Science Board.
> 4. The Foundation, upon request, will inform the principal investigator/project director of the reasons for its decision on the proposal.
>
> The Committee applauds this initiative by the NSB and hopes that NSF's implementation of the Board directive will include a broader representation of the smaller yet equally qualified colleges and universities on NSF review and advisory panels.
>
> The Committee remains keenly aware of the need for the Foundation to improve its methods of coordinating research with other federal agencies, disseminating research results to actual or potential users, and evaluating the quality and utility of final research results. The Committee recognizes the recent establishment of the Office of Planning, Coordination and Evaluation, under the direction of the Assistant Director for Research, as a step in the right direction. Nevertheless, the Committee reiterates its hope that this interim solution to a pervasive problem at NSF will only be a first assault on the problems surrounding these crucial responsibilities of the agency.[179]

This Senate report was equally articulate in dealing with the Foundation's education program:

> *Science Education.*—For Science Education Improvement activities at NSF, the Committee is recommending an appropriation of $41,000,000. This figure is $9,000,000 below the budget estimate and $19,000,000 under the amount contained in the House bill. The Committee agrees with the House that funds available for such Science Education programs and deferred in fiscal year 1795 shall be available in fiscal year 1976. In addition to the $5,500,000 deferred for the institutional support program, which may be used for science education activities, the Senate action will make $50,500,000 available which is $3,500,000 less than NSF planned to obligate in fiscal year 1976. In addition, the Committee concurs with the House action denying funds for the Instructional Improvement Implementation program and with reapplication of the $9,200,000 available for this program to supplement the funds available, proportionately, for other programs within Science Education.
>
> The Committee agrees with the House that not more than $1,000,000 shall be used for a program of Ethical and Human Value Implications.
>
> The Committee concurs with the sentiment expressed in the House report regarding the controversy surrounding the pre-college science curriculum development program. It is certainly not the intention of the Committee to erect legislative barriers in the path of innovative science curriculum; however, at a time when Federal dollars are scarce and the public is particularly sensitive to changes in the traditional educational curriculum being adopted by school systems, the Committee urges the Foundation to make a commitment to be more responsive and, sensitive to the taxpaying parents whose children will be affected by these new value-oriented social science courses.
>
> In the same vein, the Committee recognizes the fine distinction between "orientation" and "implementation" in the area of science education, but nevertheless shares the House concern that the Federal Government should not be in

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[179] Ibid., p. 58, 59, 60.

> the business of marketing curricula developed with tax dollars nor in the habit of funding efforts by developers to do the same. Federally supported curriculum development projects should rise or fall on their merits and the government should not be a party to influencing the school systems' decision to adopt or not to adopt a particular program for its pupils. Therefore, the Committee agrees that no funds should be included in the bill in fiscal year 1976 for the implementation of courses being developed under the "Instructional Improvement Implementation" line items in the elementary and secondary school programs under the general heading of "Science Education Improvement" at NSF.
>
> During the course of the budget hearings on the fiscal year 1976 budget of the National Science Foundation, the Committee learned that there is a potential bookkeeping problem connected with the Science Education Improvement program's handling of grantee royalty accounts. Grant recipients in this program receive funds from the Foundation, some of which go toward the production of trial educational materials. These materials are subsequently distributed to trial users and the grantee may charge enough to cover his costs, plus an additional amount to allow him to continue his work. The researchers then may use the income from these materials to produce a second set of educational materials, without having to go back to NSF for continuation grants. Once the materials have been perfected, they are often sold commercially to publishers and the royalties accrue to the grantee, who in many cases is authorized by NSF to hold onto this income for use to cover further expenses associated with the grant. According to NSF records, the gross income from the sale of trial materials reported by grantees for the period July 1, 1969, to December 31, 1974, was over $5.6 million and, as of April of this year, over $1,000,000 is currently being held in royalty accounts by grantees.
>
> What this system does is to allow the grantees to bypass the appropriation process and the grant review process at NSF by permitting the use of this additional money to supplement the initial grant without going through further review by the agency. Furthermore, there appear to be no internal controls at NSF to prevent an unscrupulous grantee from placing the royalty money in an interest-bearing account, converting interest dollars to his private use and returning the principal when there is an accounting. One hopes this situation does not exist, but there should be safeguards to assure complete control over every dollar that is outstanding.
>
> Therefore, the Committee believes that the present system of allowing grantees to hold onto the royalty income generated by the sale of federally-developed educational materials is improper and should be terminated. At the same time, the Committee directs the Foundation to collect all monies being held in such accounts.
>
> The Committee by no means is accusing the Foundation of any impropriety in this matter, but the grantees have been given too large a degree of flexibility. Money held in royalty accounts should be returned to the agency and subsequently to the Treasury. If further grant moneys are needed by the grantees, they should be provided by NSF through the regular channels of funding.[180]

Senate debate on H.R. 8070 did not focus on the MACOS issue, and the bill passed the Senate on July 26, 1975. Differences between the two houses were resolved in conference, but the MACOS situation was not directly involved in discussions. However, the issue was clearly not dead, but only awaiting a more appropriate time for further attention. It would seem that NSF must now undertake to improve its management in the education area, as well as in several other areas. Presumably something more fundamental than a restructuring is needed to reestablish Congressional confidence in the Foundation's management.

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[180] Ibid. p. 63, 64.

VII. A Brief Review and Evaluation

Though there have been problems in the education programs of the National Science Foundation, the contributions of this NSF effort have been an important asset to the Nation in the past 20 years. The condition of pre-college education in the United States prior to the "Sputnik Era" was so very poor that undergraduate science educators were often tempted to completely discount a student's high school science training when he or she entered college.[181]

The programs of the National Science Foundation changed that picture. In a very short time good science curricula became available for the Nation's classrooms to replace texts that often were not only poorly written but also factually incorrect, and teachers were able to obtain sound instruction in science. Though the impetus for the curriculum revision effort came from outside of the Foundation, particularly from highly motivated senior research scientists and later from pre-college teachers and administrators, the NSF did respond with the support that was demanded. While the pattern for the institutes program to train pre-college teachers in science was a well developed format prior to the existence of the Foundation, and even though NSF was at first reluctant to become involved in pre-college education, it soon made the institutes program into a national effort that would be the means of revolutionizing high school, and later on elementary and junior high school, science education.

The value of these programs seems to lie in the future, as well as in the past. There would seem to be sound reasons for their continuation within the National Science Foundation, possibly under the format that existed prior to 1970. Because these programs depend upon a continuing and creative input from active scientists, and in certain important instances require the participation of some of the Nation's most outstanding scientists, it would seem that no other agency's management could adequately be substituted for that of the National Science Foundation.

Since the late 1960's, the Foundation has apparently been under considerable pressure from OMB to avoid activities that might constitute continuing aid to education. This influence would seem to have coincided with an increasing concern, in the National Science Board and among the senior NSF administration, about problems associated with university research support. At about this time, NSF began a major redirection of its pre-college programs, saying that its educational reprogramming was necessitated by the following facts, which now appear to have been unverified assumptions:

1. The great majority of institute attendees were teachers who had attended other institute sessions; and
2. By 1974 about 50% of the high school science teachers had attended at least one institute and the other 50% could not be reached through the voluntary participation format of the institutes.

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[181] See Krieghbaum and Rawson., Op. Cit.

The impression seemed to be that little constructive educational benefit was to be obtained by repeated attendance at institutes. The public record does not seem to indicate NSF's consideration of whether institutes were serving the legitimate needs of some teachers to master a second or third discipline, or to return after a number of years to learn of recent advances in scientific knowledge or teaching method. Nor, in the 1970's was there evidence of an awareness of the lessons of the 1950's, when NSF adopted the institute format to overcome the problem of how to get knowledgable scientists involved in teaching the sort of science courses that teachers need. In summary, the Foundation's analysis seems to have been influenced by some strong preconceptions, as indicated by Dr. McElroy's testimony at the time when NSF was just starting to consider the future structure of its pre-college education activities:

> Dr. McElroy. The major cutback is in summer institutes for high school teachers. As Dr. Fontaine indicated, 40 percent of our high school teachers have now participated in one or more of these.
>
> Unfortunately we don't have, but hope to know by the end of the year, how much further we can really go in reaching the football coach who is assigned to teach biology at the high school level.[181]

A. THE QUESTION OF PRE-SERVICE SCIENCE TRAINING

While it might seem reasonable that teachers should be able to obtain adequate science training during their pre-service training, there may be reasons why this does not occur. One reason might be that the undergraduate curricula of schools and colleges of education do not seem to be able to be restructured to include sufficient science training. Adequate minimal training for science teaching at any pre-college level would seem to require not one, but several courses; which would seem to coincide with NSF's experience that institute attendees seem to want to return again and again. As a result, science training for teachers has come to be regarded as a part of their graduate training.

A second reason might be that students in schools and colleges of education find that there are few science courses available to them which meet their needs. Schools and colleges of education do not generally feel it appropriate to try to teach science, while science departments at universities feel it is inappropriate to offer science courses geared to the needs of teachers as a university offering.

On the other hand, the NSF institutes have provided an acceptable format for the teaching of science to pre-college teachers by college and university faculty, and institutes have not required the use of funds needed for other purposes within science departments. Furthermore, under the former institutes format, teachers could apply and enter at their own discretion without permission or nomination from their job superiors; and they could repeat courses as needed, either to master a topic that had proven too difficult at first exposure or to refresh their training.

Rather than criticising the institutes for their presumed, but apparently questionable, failure to reach 50% of the high school teachers who would be expected to benefit from such training, perhaps the Foundation should have been impressed that as many as 50% of those teachers felt that the institutes were of sufficient value to have been willing to invest considerable time, and often a substantial amount of money, to attend. In addition, the enhanced capability of those who have attended may well have indirectly benefited the presumed 50 percent of the pre-college teachers of science who may not have attended.

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[181] / U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development Hearings, 91st Congress, 2nd session. 1971 National Science Foundation Authoization. Washington, U.S. Govt. Print. Off., 1970. p. 202.

B. THE QUESTION OF CURRICULUM DEVELOPMENT AND IMPLEMENTATION

The problems in curriculum development and implementation are complex, but a number of factors seem to be worth considering. Commercial firms have traditionally been the developers of texts, but according to NSF statements they have only recently begun to market multi-media curricula, a field that NSF grantees seem to have pioneered and which commercial firms seem at last to be emulating. However, the cost of developing such pioneering curricula is great enough that private publishing firms are said to be reluctant to develop totally new curricula in an area or to try fundamentally new instructional methods.

Publishers have apparently been reluctant to accept completed NSF curricula for marketing in some cases because of the financial risks. By allowing publishers to incorporate parts of NSF curricula in their privately developed curricula, by setting strong examples for modern content quality and instructional methods, and by training teachers in modern methods of teaching science, NSF would seem to have stimulated and aided private publishers. Were NSF to withdraw from this area of activity, pre-college curricula might become more static, and might thereby begin a slow deterioration toward their former obsolescence.

However, the Foundation might find it preferable to make its curricula available to publishers through public competition from now on. And it might also find it advantageous to avoid such a heavy preponderence of its own curricula in the various institutes.

It would appear that recent criticisms might be allayed if NSF were to avoid such direct efforts to aid schools in the adoption of new science curricula. It would seem that the institutes might well resume their former emphasis on modern methods of teaching science and on modern course content and avoid activities which seek to service the needs of particular schools or of particular school systems in adopting new curricula. With an emphasis on raising teacher competence, current difficulties might be avoided.

It may be that the original subject-oriented institutes provided an effective and acceptable means of encouraging the adoption of improved curricula by schools and school systems by providing training to both those who would make important decisions regarding science instruction and to those who would teach. A preliminary analysis of approximately 11,000 replies to an NSF survey of graduates of academic year institutes showed that, in about 1970, some 20% of state science supervisors and some 27% of state mathematics supervisors in the United States had graduated from these institutes.

While it is reported that the analysis of the data of this survey has not been carried beyond the preliminary stage, the FY 1971 activities report of the NSF Division of Pre-College Education in Science provided the following information:[181b]

This year a survey has been made to assess what use participants have made of the training provided in Academic Year Institutes. A preliminary analysis of some 11,000 completed questionnaires obtained in the course of an on-going survey of 1957–69 AYI "graduates" revealed the following:

PRESENT EMPLOYMENT OF ACADEMIC YEAR INSTITUTES "GRADUATES"

Employment category	Respondents in category		Leadership role	
	Number	Percent of total	Number	Percent of category
Precollege education	6,571	60.5	2,592	39.4
Community college	1,102	10.2	212	19.2
4-yr college or university	1,956	18.0	614	31.4
Government, education-associated (any level)	176	1.6	73	41.5
Other employment, education-associated	173	1.6	65	37.6
Employment outside of education	394	3.6	NA	NA
Not in labor force	490	4.5	NA	NA
Total	10,862	100.0	3,556	

1. Less than 4 percent have left education. An additional 4.5 percent are women temporarily out of the classroom for family reasons, retired persons, or students working on graduate degrees full-time.

2. The 1.6 percent now involved in government education-associated activities includes 20 percent of the State Science Supervisors and 27 percent of the State Mathematics Supervisors in the country.

3. Even when graduates join the staffs of four-year institutions, as 18 percent did, they not only maintain their interest in secondary education, but become instrumental in initiating high school teacher-education activities at their home institutions. For example, during the past academic year, AYI graduates served as directors or associate directors in nine of the 67 AYI's; in 31 of the 438 SI's; and in 22 of the 281 ISI's. [Note: SI-Summer Institute; ISI-In-Service Institute].

4. The 10 percent now teaching in two-year institutions were probably hired as classroom teachers because of their subject-matter mastery. Far fewer of them play a leadership role in teacher education than in any other category listed; possibly because of the nature of the two-year institution.

5. Over 60 percent of the graduates, who constitute somewhat less than eight percent of the present population of science and mathematics teachers, have remained in secondary education, with almost 40 percent of these playing the leadership roles listed in the accompanying figure. [Below.]

TYPES OF POSITIONS CURRENTLY HELD BY "GRADUATES" OF ACADEMIC YEAR INSTITUTES EMPLOYED AT PRECOLLEGE LEVEL

	Number	Percent
Classroom teacher	3,979	60.6
Department head	1,211	18.4
Supervisor or resource teacher, science/mathematics	855	13.0
Administration in general, school or school system	446	6.8
Other	80	1.2
Total	6,571	100.0

C. CONSIDERATIONS FOR THE FUTURE

In addition to the specific measures which the Foundation might take to improve its education programs, it seems appropriate here to consider whether there are some more fundamental matters which might be considered in the hope of improving and strengthening the Foundation so as to discourage the development of similar problems in other areas. The Bauman Amendment offered one method of obtaining such assurance. However, the Bauman Amendment was not retained in the authorization bill, perhaps because of the burden which Congress would have to face in monitoring some 15,000 NSF grant actions each year, or perhaps because it demanded an unusual degree of congressional involvement in the daily operations of an executive branch agency.

[181b] National Science Foundation. Activities report of the Division of Pre-College Education, in Science for fiscal year 1971, National Science Foundation, Washington, D.C., July 1971, pp. 13, 14, 15.

Rather than using such an approach, or attempting to legislate specific operational procedures for the Foundation to follow, it might be preferable to seek a means to make appropriate changes in the Foundation's structure so as to reduce the future possibility of such strong concerns in Congress.

A number of questions arise from an examination of the history of these programs that might provide a lead to understanding where the current structure of the Foundation might be improved. For instance, why did NSF respond to OMB's antipathy for continuing programs in pre-college education by undertaking new activities which involved it so closely with the implementation of curricula in particular schools and school systems? This action would seem to have demanded major policy considerations, particularly in the face of the repeated cautions from Congress about the danger of such involvement.

A second question might be, why did NSF maintain its policy of outside decisionmaking in the educational areas? It would seem that the curriculum area in particular demanded internal product review, and that the potential for public criticism of the content of curricula was significantly increased as the Foundation made curriculum implementation a definite objective after 1970. A greater measure of staff initiative and independent staff judgement might have aided in identifying the problems that arose.

Why then—after specific suggestions from the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics in 1966 [182] and from the NSF Advisory Committee for Science Education in 1970 [183] that the Foundation staff try to be less "passive" and less heavily dependent on external leadership and judgement—was there no indication in the hearings testimony of an effort to determine whether the operational rules, practices and policies of the Foundation might be responsible for the problem, and might be encouraging the staff not to exercise independent judgement where appropriate? These sorts of questions would appear to be the particular responsibility of the National Science Board, in its role as the policymaking body for the NSF.

In addition to these, there are more specific questions about the Board's actions. For instance, why is there no indication in the many Foundation statements relating to the Platt Report [184] of a critical examination by the Board of the bases for the Report's recommendations or of its omission of factual data about the institutes and other pre-college activities? An internal memorandum by NSF staff indicated that a good deal of important statistical information could have been developed that would have provided valuable background and might have indicated other directions for the NSF institutes than the curriculum implementation route. At present, however, it is impossible to determine from the public record, or apparently from internal NSF analyses performed to date, whether the Platt Report recommendations were reasonable.

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[182] U.S. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development. Report. The National Science Foundation, its present and future. Committee print. Washington, 1966. U.S. Govt. Print. Off. p. xii, xiii.

[183] National Science Foundation. Science education—the task ahead for the National Science Foundation. NSF 71-15. U.S. Govt. Print. Off. Washington, D.C. 1970. p. 31. (The "Platt Report.")

[184] Ibid. See also the discussion for fiscal year 1970.

Perhaps more important is the question of why the National Science Board apparently approved the major restructuring and redirection of the Education Directorate recommended by Dr. Bisplinghoff's "Task Force" in 1972 without a full policy review. There seems to be little, if any, indication in the record of congressional hearings that the Board fully examined the new policies under which the new education programs would begin to operate in fiscal year 1974.

If it did make such a policy review, why did the Board not heed congressional advice about the dangers of apparent direct Federal involvement in pre-college instruction?

Why did the Board, whose members are eminent in science and are certainly not people to act on conjecture, not demand that the Foundation provide accurate numerical information about its education activities—particularly when Dr. Bisplinghoff's report stated in its abstract (i.e. on the first page) that: "The analysis was hampered by a *lack of knowledge and data* both as to problems and as to the effectiveness of various mechanisms available to NSF for solving problems?"

As the policymaking body, it would seem to be the National Science Board's proper responsibility to require that such information accompany recommendations for major changes in NSF programs, in its policies, or in its methods of operation. In private conversations conducted in the course of this study, senior Foundation officials acknowledged that, at the time of this writing, there are no available figures concerning such matters as:

1. How many different individuals attended the institutes (except for the unofficial study by a staff member in 1970—see the discussion for fiscal year 1970 for these data)?
2. What proportion of attendees were "new" each year and how many were "repeaters"?
3. Of the "repeaters", how many were involved in a definite program, leading to an advanced degree, which required taking a sequence of institute courses?
4. Of the "repeaters" not in such degree programs, how many were actually taking a course for a second time and how many were trying to gain skill in a new field—*and* of this last group how many had reason to feel that this additional knowledge would be immediately applicable in the courses which they taught or in their other assigned duties?

It was reported by these NSF officials that the only data available at the time of this writing are the numbers of stipends provided in institute-related grants. However, they pointed out that the number of individual teachers who attended the three kinds of institutes cannot be determined from the number of stipends because of repeated attendance by many individuals.

Official NSF statements have often stated that the institutes had reached 50 percent of the high school science teachers. These statements implied that the institutes had failed to reach the remaining 50 percent of high school science teachers and that therefore institutes were attracting few "new" applicants. Recent discussions indicate that these figures and conclusions have not been substantiated either by direct data or by a survey of high school teachers. It would therefore seem important to ask why the Board failed to ask for more substantive information in approving Dr. Bisplinghoff's plans for revising the Foundation's education programs.

Finally, it would seem from this study that the NSF management has had difficulty in resolving the differing priorities and objectives of the Congress, the Office of Management and Budget, the National Science Board, and the scientific community—the views of this last group being articulated both directly from scientists and through the Board. The situation of the Director of the Foundation would seem to be complicated by the need to maintain a sufficient consensus between these groups for the Foundation to be able to carry on its work. It might therefore be appropriate to consider what steps might be taken to simplify this picture of competing imperatives that surround the Foundation's director.

FISCAL YEAR 1952 Total $1,540,171		FISCAL YEAR 1953 Total $1,407,188		FISCAL YEAR 1954 Total $1,887,767		FISCAL YEAR 1955 Total $2,099,496	
Fellowships	$1, 532, 971	Fellowships	$1, 366, 344	Fellowships	$1, 726, 978	Fellowships	$1,783,706
Graduate	1, 532, 971	Graduate	1, 366, 344	Graduate	1, 726, 978	Graduate	1,783,706
Research education in the sciences	7, 200	Education in the sciences	40, 844	Education in the sciences	160, 789	Education in the sciences	315,790

FISCAL YEAR 1956

Total $3,521,134

Fellowships	$2,076,859
Graduate	1, 578, 560
Regular postdoctoral	348, 367
Senior postdoctoral	149, 932
Education in the sciences	1,434,275
Teacher training	1, 119, 970
Summer institutes:	
High school teachers, college teachers	(615, 270)
Academic year institutes	(504, 700)
Student programs	279, 440
Visiting scientists	(114, 440)
Student participation	(165, 000)
Regional conferences for improvement of science training	17, 410
Program development and appraisal	17,455

FISCAL YEAR 1957

Total $14,698,298

Fellowships	$3,353,605
Graduate	1,867,005
Regular postdoctoral	423,928
Senior postdoctoral	387,598
Science faculty	675,074
Institutes	9,629,686
Academic year	4,250,885
Secondary school	(4, 250, 885)
Summer	5,216,501
College teachers	(278,048)
Secondary school	(4, 938, 453)
In-service	162, 300
Secondary school	(162, 300)
Special projects	688,185
Visiting scientists	110,700
Traveling science libraries	179,060
Traveling demonstration lecturers	115,800
Science clubs	29,200
State academies of science	12,100
Career information	14,700
Supplementary training	226,625
Course content improvement	629,840
Scientific manpower information	279,465
President's Committee on Scientists and Engineers	117,517

FISCAL YEAR 1958

Total, $20,398,468

Fellowships	$5, 602, 120
Graduate	2, 601, 634
Regular postdoctoral	724, 811
Senior postdoctoral	695, 553
Science faculty	1, 580, 122
Institutes	12, 212, 030
Academic year	4, 906, 500
Secondary school	(4, 906, 500)
Summer	6, 684 414
College teachers	(285, 079)
Secondary school	(6, 399, 335)
In-service	621, 116
Secondary school	(621, 116)
Special projects	555, 235
Secondary school programs	389, 000
Visiting scientists	(50, 000)
Traveling libraries	(75, 000)
Traveling demonstration lectures	(75, 000)
Science clubs	(125, 000)
Student summer training	(30, 000)
State academies of science	(14, 000)
Career information	(20, 000)
College program	166, 235
Visiting scientists	(50, 000)
Teacher training	(86, 235)
Resident participation for teacher training	(30, 000)
Course content improvement	835, 372
Elementary and junior high school	6, 050
Secondary school	665, 425
College and university	56, 169
Supplementary teaching aids	107, 728
Program development and evaluation	984, 931

FISCAL YEAR 1959

Total, $64,355,784

Fellowships	$13, 070, 838
Graduate	3, 185, 459
Cooperative graduate	3, 685, 300
Summer fellowships for graduate teaching assistants	513, 763
Regular postdoctoral	1, 115, 850
Senior postdoctoral	767, 584
Science faculty	2, 327, 592
Summer fellowships for secondary school teachers	1, 475, 290
Senior foreign scientists	0
Institutes	33, 247, 999
Academic year	8, 937, 650
College teachers	(138, 200)
Secondary school	(8, 799, 450)
Summer	22, 108, 287
College teachers	(1, 952, 769)
Secondary school	(19, 617, 618)
Elementary school	(470, 300)
Technical teachers	(67, 600)
In-service	1, 941, 652
Secondary school	(1, 861, 052)
Elementary school	(80, 600)
Advanced science seminars and conferences	260, 410
College teacher conferences	(260, 410)
Special projects	8, 940, 905
Science education for students	6, 535, 223
Science education for teachers	2, 380, 569
Public understanding of science	25, 113
Course content improvement	6, 030, 325
Elementary and junior high school	558, 910
Secondary school	3, 519, 000
College and university	210, 950
Supplementary teaching aids	1, 741, 465
Science education and personnel studies	780, 285
Program development, operation and evaluation	2, 285, 432

FISCAL YEAR 1960

Total $66,907,353

Fellowships	$13, 391, 316
Graduate	3, 385, 951
Cooperative graduate	4, 121, 412
Summer fellowships for graduate teaching assistants	559, 586
Regular postdoctoral	1, 060, 469
Senior postdoctoral	737, 780
Science faculty	2, 258, 458
Summer fellowships for secondary school teachers	1, 267, 660
Senior foreign scientists	0
nstitutes	33, 873, 490
Academic year	9, 222, 117
College teachers	(208, 800)
Secondary school	(9, 013, 317)
Retired military	0
Summer	21, 926, 776
College teachers	(1, 909, 765)
Secondary school	(19, 404, 721)
Elementary school	(514, 146)
Technical teachers	(98, 144)
In-Service	2, 138, 839
Secondary school	(2, 067, 464)
Elementary school	(71, 375)
Advanced science seminars and conferences	585, 758
Advanced science seminars	(320, 920)
College teacher conferences	(264, 838)
Course content improvement	6, 419, 341
Elementary and junior high school, secondary school	4, 522, 285
College and university	1, 897, 056
Research participation and scientific activities for teachers	2, 412, 946
Science education for undergraduate students	2, 871, 482
Science education for secondary school students	4, 457, 736
Public understanding of science	316, 501
Scientific personnel and education studies	891, 075
Program development, operation and evaluation	2, 273, 466

FISCAL YEAR 1961

Total $66,824,249

Fellowships	$13, 119, 432
Graduate	4, 110, 936
Cooperative graduate	3, 485, 173
Summer fellowships for graduate teaching assistants	599, 323
Regular postdoctoral	1, 095, 014
Senior postdoctoral	705, 556
Science faculty	2, 323, 430
Summer fellowships for secondary school teachers	800, 000
Senior foreign scientists	0
Institutes	34, 500, 102
Academic year	9, 500, 035
College teachers	(381, 700)
Secondary school	(9, 118, 335)
Retired military	0
Summer	21, 118, 610
College teachers	(1, 923, 464)
Secondary school	(18, 553, 188)
Elementary school	(641, 958)
In-service	2, 763, 068
Secondary school	(2, 571, 056)
Elementary school	(192, 012)
Advanced science seminars and conferences	1, 118, 389
Advanced science seminars	(776, 578)
College teacher conferences	(341, 811)
Secondary school teacher conferences	0
Course content improvement	6, 410, 871
Elementary and junior high school	456, 480
Secondary school	2, 888, 772
College and university	1, 328, 941
Supplementary teaching aids	1, 736, 678
Research participation and scientific activities for teachers	2, 647, 437
College teachers	1, 782, 679
Secondary teachers	864, 758
Science education for undergraduate students	3, 387, 775
Science education for secondary school students	3, 049, 896
Public understanding of science	326, 679
Scientific personnel and education studies	1, 018, 585
Program development, operation and evaluation	2, 363, 472

FISCAL YEAR 1962

Total $78,580,448

Fellowships	$16, 800, 000
Graduate	5, 533, 000
Cooperative graduate	4, 176, 990
Summer fellowships for graduate teaching assistants	846, 000
Regular postdoctoral	1, 403, 510
Senior postdoctoral	945, 000
Science faculty	3, 085, 500
Summer fellowships for secondary school teachers	810, 000
Senior foreign scientists	0
Institutes	40, 875, 972
Academic year	10, 890, 372
College teachers	(529, 358)
Secondary school	(10, 361, 014)
Summer	26, 034, 103
College teachers	(2, 320, 689)
Secondary school	(23, 018, 765)
Elementary school	(694, 649)
In-service	3, 523, 536
Secondary school	(3, 327, 325)
Elementary school	(196, 211)
Advanced science seminars and conferences	427, 961
Advanced science seminars	(0)
College teacher conferences	(427, 961)
Secondary school teacher conferences	(0)
Course content improvement	8, 989, 756
Elementary and junior high school	1, 715, 675
Secondary school	3, 980, 090
College and university	1, 268, 723
Supplementary teaching aids	2, 025, 268
Research participation and scientific activities for teachers	2, 374, 450
Science education for undergraduate students	4, 372, 639
Science education for secondary school students	3, 419, 051
Summer program for high school students	1, 810, 431
Cooperative college-school science	520, 821
Specialized activities	1, 087, 799
Specialized advanced science education	1, 405, 779
Advanced science seminars	999, 482
Public understanding of science	294, 327
Science education developmental projects	111, 970
International science activities, education	342, 801

FISCAL YEAR 1963

Total $90,987,376

Fellowships	$21, 678, 136
Graduate	7, 600, 000
Cooperative graduate	5, 355, 727
Summer fellowships for graduate teaching assistants	950, 000
Regular postdoctoral	1, 471, 201
Senior postdoctoral	964, 000
Science faculty	3, 799, 000
Summer fellowships for secondary school teachers	861, 000
Senior foreign scientists	677, 199
Institutes	41, 804, 084
Academic year	11, 059, 253
College teachers	(555, 184)
Secondary school	(10, 504, 069)
Summer	26, 595, 245
College teachers	(2, 470, 328)
Secondary school	(23, 079, 721)
Elementary school	(1, 045, 196)
In-service	3, 509, 914
Secondary school	(3, 193, 020)
Elementary school	(293, 194)
College teachers	(23, 700)
Advanced science seminars and conferences	639, 672
College teacher conferences	(639, 672)
Course content improvement	12, 632, 408
Elementary and junior high school	2, 938, 475
Secondary school	3, 675, 703
College and university	3, 009, 679
Supplementary teaching aids	3, 008, 551
Research participation and scientific activities for teachers	2, 559, 079
Science education for undergraduate students	5, 878, 348
Science education for secondary school students	3, 682, 732
Student science training	2, 180, 917
Cooperative college-school science	750, 978
Specialized activities	750, 837
Specialized advanced science education	2, 752, 589
Advanced science seminars	1, 501, 780
Public understanding of science	368, 748
Science education developmental projects	882, 061

FISCAL YEAR 1964

Total $102,580,373

Fellowships, traineeships	$30, 105, 000
Graduate fellowships	9, 036, 316
Cooperative graduate	6, 135, 000
Summer fellowships for graduate teaching assistants	961, 000
Regular postdoctoral	1, 631, 540
Senior postdoctoral	1, 028, 650
Science faculty	3, 838, 810
Summer fellowships for secondary school teachers	855, 000
Senior foreign scientists	618, 684
Graduate traineeships	6, 000, 000
Institutes	43, 246, 729
Academic year	11, 710, 929
College teachers	(1, 228, 940)
Secondary school	(10, 481, 989)
Summer	27, 349, 223
College teachers	(3, 015, 948)
Secondary school	(23, 092, 913)
Elementary school	(1, 240, 362)
In-service	3, 558, 540
Secondary school	(3, 107, 661)
Elementary school	(450, 879)
Advanced science seminars and conferences	628, 037
College teacher conferences	(628, 037)
Course content improvement	13, 975, 712
Elementary and junior high school	4, 493, 397
Secondary school	4, 412, 371
College and university	1, 904, 289
Supplementary teaching aids	3, 165, 655
Research participation and scientific activities for teachers	3, 714, 884
Science education for undergraduate students	6, 051, 566
Science education for secondary school students	3, 918, 672
Student science training	2, 304, 593
Cooperative college-school science	720, 674
Specialized activities	893, 405
Specialized advanced science education	1, 567, 810
Science education improvement	1, 172, 038
Public understanding of science	395, 772

FISCAL YEAR 1965

Total $120,414,677

Fellowships, traineeships	$40, 224, 075
Graduate fellowships	9, 617, 000
Cooperative graduate	6, 295, 759
Summer fellowships for graduate teaching assistants	979, 000
Regular postdoctoral	1, 625, 904
Senior postdoctoral	1, 061, 240
Science faculty	4, 097, 700
Summer fellowships for secondary school teachers	826, 000
Senior foreign scientists	660, 583
Graduate traineeships	15, 060, 889
Institutes	43, 196, 261
Academic year	11, 749, 231
College teachers	(1, 153, 197)
Secondary school	(10, 596, 034)
Summer	27, 140, 880
College teachers	(2, 940, 291)
Secondary school	(22, 950, 101)
Elementary school	(1, 250, 488)
In-service	3, 657, 068
Secondary school	(3, 217, 994)
Elementary school	(439, 074)
Advanced science seminars and conferences	649, 082
Course content improvement	14, 551, 867
Elementary and junior high school	5, 652, 800
Secondary school	3, 617, 987
College and university	5, 281, 080
Supplementary teaching aids	0
Research participation and scientific activities for teachers	4, 003, 610
Research participation	2, 108, 726
Visiting scientists	898, 814
Special activities	996, 070
Science education for undergraduate students	5, 478, 698
Science education for secondary school students	3, 402, 592
Student science training	2, 130, 622
Cooperative college-school science	848, 116
Specialized activities	423, 854
Specialized advanced science education	1, 352, 990
Instructional equipment for undergraduate education	8, 204, 584

FISCAL YEAR 1966

Total, $124,305,225

Fellowships, traineeships	$44, 484, 949
Graduate fellowships	12,180,550
Cooperative graduate	1,471,390
Summer traineeships for graduate teaching assistants	990,000
Regular postdoctoral	1,580,000
Senior postdoctoral	1,082,550
Science faculty	4,160,000
Senior foreign scientists	672,550
Graduate traineeships	22,347,909
Institutes	41, 618, 540
College teachers	3,896,237
Secondary school	35,433,588
Elementary school	1,200,775
Advanced science seminars	1,087,940
Course content improvement	15, 563, 952
Precollege	9,916,681
Undergraduate	5,647,271
Research participation	2, 982, 621
College teachers	1,381,023
High school teachers	719,237
Precollege supplemental projects	882,361
Science education for students	11, 919, 118
Undergraduate	6,582,865
Secondary	1,972,500
Cooperative college-school science	1,957,426
Special projects (undergraduate)	1,406,327
Instructional equipment for undergraduate education	7, 736, 045

FISCAL YEAR 1967

Total, $123,360,166

Fellowships, traineeships	$45, 874, 427
Graduate fellowships	11,894,576
Summer traineeships for graduate teaching assistants	1,059,593
Postdoctoral fellowships	1,201,000
Senior postdoctoral fellows	774,405
Science faculty	3,330,000
Senior foreign scientists	643,800
Graduate traineeships	26,971,053
Institutes	37, 928, 937
Secondary level	33,453,599
Summer	(21,315,608)
Academic year	(9,184,194)
In-service	(2,953,797)
College level	4,475,338
Summer	(3, 014,688)
Academic year	(874,056)
Short courses, seminars	(586,594)
Course content improvement	18, 355, 444
Mathematics, K–12	2,877,850
Elementary and junior high school science	3,809,587
Secondary science	5,002,263
College and university	6,665,744
Research participation and scientific activities for teachers	3, 890, 227
Secondary teachers	1,218,390
College teachers	1,518,839
Advanced seminars	1,152,998
Science education for students	6, 804, 080
Secondary students	2,069,815
Undergraduates	4,734,265
Cooperative college-school science	2, 212, 537
Special projects	3, 388, 394
Precollege	590,690
Undergraduate	685,943
Graduate	2,111,761
Instructional equipment for undergraduate education	4, 906, 120

FISCAL YEAR 1968

Total $124,832,567

Fellowships, traineeships	$46, 057, 371
Graduate fellowships	9, 912, 363
Summer traineeships for graduate teaching assistants	1, 063, 102
Postdoctoral fellows	663, 500
Senior postdoctoral fellows	537, 901
Science faculty	2, 864, 768
Senior foreign scientists	786, 432
Graduate traineeships	30, 229, 305
Institutes	38, 327, 747
Secondary level	34, 224, 727
Summer	(22, 121, 886)
Academic year	(8, 449, 385)
In-service	(3, 653, 456)
Undergraduate	4, 103, 020
Course content improvement	19, 352, 297
Mathematics K–12	3, 887, 264
Elementary and junior high school science	5, 266, 558
Secondary science	4, 153, 421
Undergraduate	6, 045, 054
Research participation and scientific activities for teachers	3, 985, 786
Secondary teachers	1, 234, 972
College teachers	1, 612, 687
Advanced seminars	1, 138, 127
Science education for students	6, 208, 386
Secondary students	2, 066, 786
Undergraduates	4, 141, 600
Cooperative college school science	3, 386, 732
Special projects	2, 808, 459
Precollege	433, 078
Undergraduate	905, 718
Graduate	1, 469, 663
Instructional equipment for undergraduate education	4, 335, 789
Preservice teacher education	370, 000

FISCAL YEAR 1968

Budget Revision No. 1

Precollege education	$54, 653, 538
Institutes	34, 224, 727
Course content improvement	13, 307, 243
Research participation and scientific activities for teachers	1, 234, 972
Science education for students	2, 066, 786
Cooperative college-school science	3, 386, 732
Special projects	433, 078
Undergraduate education	21, 513, 868
Institutes	4, 103, 020
Course content improvement	6, 045, 054
Research participation	1, 612, 687
Science education for students	4, 141, 600
Special projects	905, 718
Instructional equipment	4, 335, 789
Preservice teacher education	370, 000
Graduate education	48, 200, 000
Fellowships, traineeships	46, 057, 371
Advanced science education	2, 607, 790
Special projects	(1, 469, 663)
Advanced seminars	(1, 138, 127)

FISCAL YEAR 1969

Total $115,297,494

Precollege education	$45, 497, 286
Institutes	30, 863, 872
Course content improvement	7, 924, 535
Science education for students	1, 885, 316
Cooperative college school science	4, 823, 563
Undergraduate education	27, 334, 602
College teacher programs, institutes, et al	4, 645, 723
Science curriculum improvement	10, 208, 785
Undergraduate education in science (students)	3, 716, 394
College science improvement program	8, 763, 700
Graduate education	42, 465, 606
Fellowships, traineeships	39, 811, 547
Graduate fellowships and traineeships	(35, 870, 585)
Postdoctoral fellowships	(702, 404)
Science faculty fellowships	(2, 509, 690)
Senior foreign scientist	(728, 868)
Advanced science education	2, 654, 059

FISCAL YEAR 1969

Budget Revision No. 2

Student development	$42, 891, 295
Precollege:	
Science education for students	1, 885, 316
Undergraduate:	
Education in science	3, 716, 394
Graduate:	
Graduate fellowships and traineeships	35, 870, 585
Postdoctoral fellowships	702, 404
Advanced science education	716, 596
Instructional program development	33, 776, 481
Precollege:	
Course content improvement	7, 924, 535
Cooperative college-school science	4, 823, 563
Undergraduate:	
Science curriculum improvement	10, 208, 785
College science improvement	8, 763, 700
Graduate:	
Senior foreign scientist fellowships	728, 868
Advanced science education	1, 327, 030
Instructional personnel development	38, 629, 718
Precollege:	
Institutes	30, 863, 872
Undergraduate:	
College teacher programs (institutes)	4, 645, 723
Graduate:	
Science faculty fellowships	2, 509, 690
Advanced science education	610, 433

FISCAL YEAR 1970

Total $120,179,865

Student development	**$45, 869, 904**
Precollege:	
Science education for students	1, 930, 869
Undergraduate:	
Undergraduate research participation and student originated studies	3, 817, 318
Graduate:	
Fellowships, traineeships	37, 644, 107
Postdoctoral fellowships	1, 689, 000
Advanced science education	788, 610
Instructional program development and educational research	29, 396, 416
Precollege:	
College and curriculum development and implementation	11, 161, 401
Undergraduate:	
Science curriculum improvement	9, 805, 506
College science improvement	6, 829, 200
Graduate:	
Senior foreign scientist fellowships	779, 518
Advanced science education	820, 791
Instructional personnel development	44, 913, 545
Precollege:	
Institutes	36, 935, 931
Undergraduate:	
College teacher programs (institutes)	4, 160, 497
Graduate:	
Science faculty fellowships	3, 033, 889
Advanced science education	783, 228

FISCAL YEAR 1971

Total $98,811,231

Student development	$37, 962, 805
Precollege:	
High school student projects	2, 051, 120
Undergraduate:	
Undergraduate student projects	3, 925, 938
Undergraduate student-originated projects	1, 491, 066
Graduate:	
Graduate fellowships	9, 418, 229
Graduate traineeships	18, 046, 272
Summer traineeships for teaching assistants	1, 041, 180
Postdoctoral fellowships	1, 989, 000
Instructional program development and educational research	26, 019, 324
Precollege:	
Elementary and secondary materials	4, 359, 380
School system projects	4, 729, 900
Undergraduate:	
College and university projects (COSIP)	3, 674, 976
Preservice teacher education projects	2, 635, 277
Technician/technologist education projects	76, 500
Resource personnel projects	1, 703, 136
Undergraduate instructional materials	5, 165, 675
Graduate:	
Graduate and continuing education development	3, 574, 480
Instructional personnel development	34, 929, 102
Precollege:	
Comprehensive inservice teacher projects	117, 277
Secondary school teacher projects	23, 307, 148
Leadership specialist projects	520, 653
Undergraduate:	
College teacher projects	5, 230, 427
Graduate:	
Science faculty and senior foreign scientist fellowships	3, 914, 395
State and urban system projects	1, 839, 202

FISCAL YEAR 1971
Budget Revision No. 3
(Adopted for fiscal year 1973*)

1. SCIENCE EDUCATION IMPROVEMENT

Total $68,316,550

Scientific research, development, and demonstration	$20, 961, 993
a) Development of alternative instructional methods and materials	13, 099, 535
Elementary and secondary materials	(4, 359, 380)
Undergraduate instructional materials	(5, 165, 675)
Graduate and continuing education development	(3, 574, 480)
b) Experimental models and demonstrations	7, 862, 458
Resource personnel projects	(1, 703, 136)
Comprehensive inservice teacher projects	(117, 277)
Preservice teacher education projects	(2, 635, 277)
State and urban system projects	(1, 839, 202)
Undergraduate student-originated projects	(1, 491, 066)
Technician/technologist education projects	(76, 500)
Instructional improvement implementation	41, 377, 499
a) Training Educational personnel for implementation	32, 972, 623
Secondary school teacher projects	(23, 307, 148)
Leadership specialist projects	(520, 653)
College teacher projects	(5, 230, 427)
Science faculty and senior foreign scientist fellowships	(3, 914, 395)
b) School system and college implementation	8, 404, 876
School system projects	(4, 729, [illegible])
College and university projects	(3, 674, 976)
Talented student programs	5, 977, 058
High school student projects	2, 051, 120
Undergraduate student projects	3, 925, 938

FISCAL YEAR 1972

Total $93,728,301

1. SCIENCE EDUCATION IMPROVEMENT

Total $73,388,40[illegible]

Scientific research, development, and demonstration	$22, 395, 130
a) Development of alternative instructional methods and materials	10, 187, 256
Elementary and secondary materials	(3, 313, 516)
Undergraduate instructional materials	(5, 165, 675)
Graduate and continuing education	(2, 255, 253)
b) Experimental models and demonstrations	12, 207, 874
Resource personnel projects	(1, 514, 252)
Comprehensive inservice projects	(3, 363, 690)
Preservice teacher education projects	(1, 510, 802)
State and urban system projects	(2, 671, 831)
Undergraduate student-originated studies	(1, 896, 007)
Technician/technologist education projects	(1, 251, 292)
Instructional improvement implementation	36, 821, 976
a) Training educational personnel for implementation	21, 512, 313
High school teacher training projects	(16, 140, 332)
Leadership specialist projects	(2, 189, 684)
College teacher projects	(3, 182, 297)
b) School system and college implementation	15, 309, 663
School system projects	(4, 354, 659)
College and university projects	(10, 955, 004)
Talented student programs	5, 798, 928
High school student projects	1, 938, 435
Undergraduate student projects	3, 860, 493
Computer innovation in education	8, 372, 366

FISCAL YEAR 1970 Total $120,179,865	FISCAL YEAR 1971 Total $98,811,231	FISCAL YEAR 1971 Budget Revision No. 3 (Adopted for fiscal year 1973*)	FISCAL YEAR 1972 Total $93,728,301
		2. GRADUATE STUDENT SUPPORT Total $30,494,681 Graduate fellowships 9, 418, 229 Graduate traineeships 18, 046, 272 Summer traineeships for teaching assistants 1, 041, 180 Postdoctoral fellowships 1, 989, 000	2. GRADUATE STUDENT SUPPORT Total $20,339,901 Graduate fellowships 9, 897, 278 Graduate traineeships 10, 442, 623

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*Obligations for fiscal year 1971 and fiscal year 1972 have only been reported in the 1973 format. Because of several important programmatic changes occurring in fiscal year 1972, the transition is presented here.

FISCAL YEAR 1973

Total $62,233,405

1. SCIENCE EDUCATION IMPROVEMENT

Total $46,924,510

Development, research and demonstration	$15, 564, 821
a) Development of alternative instructional methods and materials	11, 161, 208
Elementary and secondary	(3, 311, 619)
Higher education	(7, 044, 057)
Public understanding	(805, 532)
b) Experimental models and demonstrations	4, 403, 613
Comprehensive projects	(948, 824)
Preservice teacher training	(366, 689)
State and urban systems	(900, 134)
Technical education	(143, 795)
Leadership institutes	(2, 044, 171)
Instructional improvement implementation	26, 175, 949
a) Training educational personnel	11, 233, 377
Supervisors and administrators	(822, 388)
Secondary teachers	(10, 410, 989)
b) School systems and colleges	8, 726, 354
School system projects	(2, 019, 563)
College and university projects	(6, 706, 791)
c) Technology in education	6, 216, 218
Student programs	5, 183, 740
High school student projects	1, 955, 251
Undergraduate student projects	2, 133, 398
Student originated studies	1, 095, 091

2. GRADUATE STUDENT SUPPORT

Total $15, 308, 895

Graduate fellowships	10, 482, 902
Graduate traineeships	4, 825, 993

FISCAL YEAR 1974

Total $80,709,308

1. SCIENCE EDUCATION IMPROVEMENT

Total $67,710,609

Development, research and demonstration	$23, 075, 513
a) Development of alternative instructional methods and materials	18, 040, 768
Elementary and secondary	(8, 260, 941)
Higher education	(7, 567, 570)
Public understanding	(2, 212, 257)
b) Experimental models and demonstrations	5, 034, 745
Comprehensive projects	(0)
Preservice teacher training	(1, 569, 800)
State and urban systems	(2, 462, 500)
Technical education	(1, 002, 445)
Leadership institutes	(0)
Instructional improvement implementation	36, 217, 246
a) Training educational personnel	11, 013, 805
Supervisors and administrators	(0)
Elementary teachers	(*2, 791, 000)
Secondary teachers	(*5, 819, 000)
College teachers	(2, 403, 805)
b) School systems and colleges	17, 771, 873
School system projects	(*6, 158, 853)
College and university projects	(11, 613, 020)
c) Technology in education	7, 431, 568
Student programs	5, 130, 313
High school student projects	1, 374, 976
Undergraduate student projects	2, 021, 961
Student-originated studies	1, 733, 376
Problem assessment and experimental projects	2, 069, 447

2. GRADUATE STUDENT SUPPORT

Total $12,998,699

Graduate fellowships	9, 776, 415
Graduate traineeships	3, 222, 284

* Estimated.

FISCAL YEAR 1974

Budget Revision No. 4

1. SCIENCE EDUCATION IMPROVEMENT

Total $67,710, 609

Improvement of education for careers in science	$28, 071, 367
a) Secondary school program	1, 517, 084
Materials development, testing and evaluation	(1, 123, 084)
Instructional improvement implementation	(394, 000)
b) Student-oriented program	5, 130, 313
Secondary school student projects	(1, 374, 976)
Undergraduate research participation projects	(2, 021, 961)
Student-originated studies project	(1, 733, 376)
c) Alternatives in higher education program	10, 706, 855
Development of instructional materials	(3, 441, 112)
Alternative degree projects	(3, 122, 773)
Technical education projects	(1, 002, 445)
Instructional scientific equipment	(3, 140, 525)
d) Continuing education and professional development	4, 715, 280
Continuing education for scientists and engineers	(1, 003, 685)
College faculty short courses	(1, 307, 790
Faculty research participation	(919, 440)
Science faculty fellowships	(1, 484, 365)
e) Ethnic minorities in science	6, 001, 835
Improvement of education for science literacy	23, 635, 267
a) Elementary school program	7, 940, 900
Materials development, testing and evaluation	(2, 050, 777)
Instructional improvement implementation	(5, 890, 123)
b) Secondary school program	13, 482, 110)
Materials development, testing and evaluation	(5, 087, 080)
Instructional improvement implementation	(8, 395, 030)
c) Public understanding of science	2, 212, 257

FISCAL YEAR 1975

Estimated Obligations

Total $74,350,000

1. SCIENCE EDUCATION IMPROVEMENT

Total $61,150,000

Improvement of education for careers in science	$28, 750, 000
a) Secondary school program	1, 400, 000
Materials development, testing and evaluation	(1, 000, 000)
Instructional improvement implementation	(400, 000)
b) Student-oriented program	5, 800, 000
Secondary school student projects	(2, 000, 000)
Undergraduate research participation projects	(2, 800, 000)
Student-originated studies project	(1, 000, 000)
c) Alternatives in higher education program	11, 850, 000
Development of instructional materials	(3, 350, 000)
Alternative degree projects	(3, 100, 000)
Technician education projects	(2, 000, 000)
Instructional scientific equipment	(3, 000, 000)
Visiting foreign energy scholars	(400, 000)
d) Continuing education and professional development	4, 700, 000
Continuing education for scientists and engineers	(1, 200, 000)
College faculty short courses	(1, 000, 000)
Faculty research participation	(1, 000, 000)
Science faculty fellowships	(1, 500, 000)
e) Ethnic minorities in science	5, 000, 000

FISCAL YEAR 1973 Total $62,233,405	FISCAL YEAR 1974 Total $80,709,308	FISCAL YEAR 1974 Budget Revision No. 4		FISCAL YEAR 1975 Estimated Obligations Total $74,350,000	
				Improvement of education for science literacy	**20,400,000**
				a) Elementary school program	**7,800,000**
				Materials development, testing and evaluation	**(2,000,000)**
				Instructional improvement implementation	**(5,800,000)**
				b) Secondary school program	**10,800,000**
				Materials development, testing and evaluation	(4,500,000)
				Instructional improvement implementation	(6,300,000)
				c) Public understanding of science	1,800,000
		Increasing effectiveness of educational processes	13,934,528	Increasing effectiveness of educational processes	10,600,000
		a) Technological innovation in education	7,431,568	a) Technological innovation in education	6,000,000
		b) Educational program restructuring	6,502,960	b) Educational program restructuring	4,600,000
		Preservice teacher training projects	(1,569,800)	Preservice teacher training projects	(1,500,000)
		Restructuring the undergraduate learning environment projects	(2,470,660)	Restructuring the undergraduate learning environment projects	(2,000,000)
		State/regional urban systems projects	2,462,500	State/regional urban systems projects	(1,100,000)
		Problem assessment and experimental projects	2,069,447	Problem assessment and experimental projects	1,400,000
		Problem assessment and experimental projects	(1,464,227)	Problem assessment and experimental projects	1,000,000
		Minorities and women student projects	(605,220)	Minorities and women student projects	400,000
		2. GRADUATE STUDENT SUPPORT		2. GRADUATE STUDENT SUPPORT	
		Total $12,998,699		Total $13,200,000	
		Graduate fellowships	9,776,415	Graduate fellowships	9,500,000
		Graduate traineeships	3,222,284	Graduate traineeships	2,300,000
				Energy-related postdoctorals	1,400,000

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APPENDIX A

NATIONAL SCIENCE FOUNDATION OBLIGATIONS FOR SCIENCE EDUCATION AS REPORTED IN ANNUAL APPROPRIATION REQUESTS

APPENDIX B

DISCUSSION BY CONGRESSMAN GEORGE P. MILLER, CHAIRMAN OF THE HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS, OF THE SHORTAGE OF SCIENTISTS AND ENGINEERS AND HIS CORRESPONDENCE ON THAT SUBJECT WITH DR. JEROME B. WIESNER, THE PRESIDENT'S SCIENCE ADVISER

Congressional Record,
Vol. 109, P. 10535 ff

June 10, 1963

NATIONAL SECURITY AND MANPOWER RESOURCES

Mr. MILLER of California. Mr. Speaker, I ask unanimous consent to extend my remarks at this point in the Record and include extraneous matter.

The SPEAKER. Is there objection to the request of the gentleman from California?

There was no objection.

Mr. MILLER of California. Mr. Speaker, President Kennedy in his budget message to the Congress has recommended a program to meet national goals that depends more heavily for its fulfillment on scientific research and development than any set of recommendations ever placed before this body.

To maintain a vigorous posture of military security, to sustain space exploration second to none, to stimulate domestic economic growth, to continue strides in medical advancement, to meet the problems of a highly urbanized society—for all these purposes we look more than ever before to the fruits of scientific discovery and their prompt conversion to technology.

Research and development appropriations proposed by the President amount to 15 percent of the total budget. These funds reflect a substantial increase since launching of the first sputnik dramatically revealed how intimately our Nation's leadership in the world would depend on a leadership in science and engineering.

We all know, however, that strength of our Nation's research and development is not simply a product of increased expenditures. Limitations on skilled manpower could throttle our effort even more critically than a limitation on budget. For the first time in our history, we may be confronted with a plurality of goals that may well outstrip our supply of scientists and engineers.

The appetite of today's technology for high-level technical manpower is tremendous. The space program furnishes one clear example of the increased sophistication in systems development; the interplay required between different scientific disciplines; the unprecedented demands for reliability. But civilian technology requires similar skills in improvement of our domestic transportation and communications systems, in keeping one technological step ahead of our competitors in world consumer and industrial markets.

In a sense, we stand at a crossroads. We have elected a number of national goals that require world technological leadership. Growth and diversity in research and development effort must be sustained. Yet the slack in the technical manpower system has been almost fully absorbed in our recent rapid expansion.

The dramatic explosion of scientific effort was made possible by a remarkable influx of gifted people in research and development functions from other occupations, by increased production of scientists and engineers through legislation which assisted World War II and Korean veterans to complete studies.

Only a few more people can be appropriately drawn away from nonresearch and development activities, or effectively accommodated in professional ranks without additional training. Moreover, considering the long leadtime for training, the new supply of scientists and engineers for the rest of this decade is already in college and thus fixed by current enrollments; and for the next decade these people are already in junior or senior high school. Growth and strength of our research and development effort will thus be critically limited by productive capacity of our educational system, and by utilization of those already engaged in research and development.

Long-term planning thus becomes essential because we cannot accept the consequences of a random development of our manpower resources to meet present goals. Moreover, the future is difficult to foresee, and we must be prepared to meet the unexpected—to exploit new scientific opportunities as swiftly in the future as we have in the past in atomic energy and in space.

The Committee on Science and Astronautics has felt a mounting concern for future manpower requirements, especially in terms of the constantly higher training required of all our technical personnel. Our concern is not unique.

The President, about a year ago—taking note of published reports on deliberate measures by the Soviet Union to develop its technical manpower—requested his Science Advisory Committee to take a careful look at this problem. With release by the White House of the first in a series of reports on manpower, I asked Dr. Jerome Wiesner, the Director of the Office of Science and Technology, to comment on specific problem areas, and on programs aimed at their solution. My letter and his reply are submitted for the record following these remarks.

The impending shortage and the most urgent need for action that Dr. Wiesner describes relate to quality, not quantity. Fulfillment of our diverse programs to which we are already committed may be threatened unless strong action is taken to increase the output from our graduate schools, particularly of more engineers, mathematicians, and physical scientists who combine high talent and high training.

For example, in 1950 we turned out 2,000 Ph. D.'s in these 3 fields; in 1960, we graduated 3,000, an increase of 50 percent. But in 1970 we need a minimum of 7,500, an increase in the decade of 150 percent. For among other sources of demand for these graduates are the universities themselves; they must accommodate the first wave of the postwar baby boom who become college applicants in 1965.

I do not like to use the Soviet achievements as a yardstick for our own activities, but can we afford to sit back while the Soviets already have three Ph. D. engineers in their ranks to every one of ours, while they train more at an even faster rate?

In this country, only about 4 percent of the B.S. graduates in engineering go on to a doctorate. Out of a group of 10,000 citizens of age 30, only about 4 have a Ph. D. in engineering. This is far too few. The study conducted for the President suggests that the manpower requirements of this decade can be met only if more students studying science and engineering—those already in the college pipeline—are encouraged to continue on to full-time graduate study.

The major barrier to such advanced study is financial. Faced with a choice of a $7,000 starting salary and a very much smaller graduate stipend, many highly qualified college graduates—especially those with family responsibilities and those who incurred debts as undergraduates—decide that they cannot afford graduate education. Others extend their study by combining part-time study with part-time work, often becoming dropouts.

Another barrier is limited graduate facilities and faculty.

To remedy these problems, following recommendations to him by his advisers, the President has placed before the Congress a program of support for graduate students and for facilities that emphasizes the number of new starts.

Both because the Federal Government is a major consumer of scientific talent, and because the problem is urgent, the President proposes a program with Federal leadership, but involving a close relationship with State and local governments, industry, and the universities.

Fellowship and training grant subventions are proposed in budgets especially of the National Science Foundation, Atomic Energy Commission, and the National Aeronautics and Space Administration, and extension and expansion of the National Defense Education Act.

These proposals would represent a deliberate first step whereby the Federal Government accepts the Nation's responsibility to assure adequacy of technical manpower resources to meet its commitments. They could provide more and better opportunities for advanced training of our able young people so that none need turn away from graduate study because of financial need, or because training facilities are inadequate or too far away.

The question has often been raised at this point whether an increase in the graduate student population would serve to undermine the quality of a graduate education. It is no doubt true that indiscriminate expansion of facilities without regard to available teaching strength, geographic location, and area of specialization, would very often do more harm than good.

But many outstanding schools would greatly appreciate a larger number of fellowships which would prevent the loss of good graduate students. Many other schools which show promise of becoming centers of excellence are so limited in funds that they cannot retain their best students for teaching and research assignments, or build much-needed laboratories and classrooms.

There are probably more untapped graduate manpower resources in some fields than in others. In the physical sciences, the percentage of students going on to receive Ph. D. degrees is as high as 18 to 20 percent. It may not be possible or desirable to increase output substantially in fields where such a high proportion do attempt graduate work.

But in other fields such as engineering where only 4 percent of those obtaining a B.S. degree go on to receive a Ph. D., it appears certain that a relatively large number of well-qualified students could be attracted toward graduate study.

In a recent survey by the Engineers Joint Council, 126 responding institutions that offer graduate engineering curriculum reported 3,160 students are now on fellowships, that an additional 6,420 fellowships could be used if available. Only 33 current fellowships are unfilled. The normal sources of financial assistance for graduate students and graduate programs just cannot be expected to expand rapidly enough to remove this graduate manpower bottleneck. We should listen to the President's Science Advisory Committee when it recommends that "an immediate, vigorous national effort to increase graduate training in engineering, mathematics, and physical sciences" be undertaken.

It is clear from Dr. Wiesner's letter that this area of graduate study is but one deserving attention. There are other serious questions regarding need for technicians, opportunities for women, retraining of those whose skills have become obsolete, and the area of manpower utilization.

In a free democratic society, we do not assign individuals by decree of a centralized manpower board. Rather, we try to maximize the opportunities and the information about these opportunities, so that our young people can exercise an independent and informed choice. But we cannot be nonchalant about this issue in the cold war atmosphere that demands continued U.S. leadership. All elements of our society must study and act—industry, universities, the Executive, and the Congress.

Because of the serious nature of this matter, because of its extreme importance to the future welfare of the Nation, and due to the impact which our present action or inaction will have upon the lives of coming generations, it is my hope and intent to inaugurate a careful and comprehensive inquiry into the status of scientific manpower. This inquiry will require careful staff preparation, which I plan to augment as soon thereafter as feasible with committee hearings to draw testimony from the country's foremost experts in scientific and technical resources.

The main purpose of the inquiry, which the Committee on Science and Astronautics will be undertaking pursuant to its charter from the House, will be to identify the problems of sufficient scientific manpower and to separate the real from the apparent.

We do not kid ourselves that this will be an easy job, and we shall be indebted to many others who have inquired into some of these difficulties from time to time in the past. However, the completed task is an urgent one which can no longer be delayed.

FEBRUARY 15, 1962.

Dr. JEROME B. WIESNER,
Director, Office of Science and Technology,
Executive Office Building, Washington, D.C.

DEAR DR. WIESNER: For some time those of us serving on the Committee on Science and Astronautics have felt a mounting concern for the future requirements the Nation faces with regard to its scientific and technical resources. This concern extends not merely to adequate research programs and well distributed facilities, but even more to that most crucial element of our national progress—scientific manpower and the constantly higher degree of training that it must have in these times.

I am aware, of course, that our concern is not unique. The recent report of your own Science Advisory Committee to the President has highlighted some of the growing difficulties in the field of scientific and technological training. Similar recognition of the problem has been evidenced by the National Academy of Sciences, the National Science Foundation, by industry and by the universities. Moreover, this same apprehension was in prominent display during this committee's annual conference last month with its Science Advisory Panel.

In my judgment, it is becoming imperative that the executive and legislative branches of the government join hands in this matter with an eye toward making the Federal effort to bolster research and technological training as effective as possible. While I think that the Nation in general has been doing a commendable job, I doubt if it will suffice in the future. The close association this committee has with the national space program and our recognition of the vast demands which this program alone is making upon our scientific resources leads me to the conclusion that better and more coordinated planning for the development of highly trained scientific talent is an absolute must in the years ahead. And, obviously, the needs of the space program are but a segment of the whole requirement.

With this background in mind, I am addressing you as Director of the Office of Science and Technology, to solicit your aid and suggestions in devising methods to pinpoint specific problem areas and in seeking avenues for their solution. It may be that a broad investigation by this committee of future scientific and technological requirements would be useful—in the course of which facts and information might be obtained from those in and out of government who are most exposed to the exigencies of our national scientific and technological effort.

Your thoughts and comments on this matter will be most welcome.

Sincerely yours,

George P. Miller,
Chairman.

Office of Science and Technology,
Washington, D.C., March 27, 1963.

Hon. George P. Miller,
Chairman, Committee on Science and Astronautics, U.S. House of Representatives, Washington, D.C.

Dear Mr. Chairman: Your recent letter on problems in scientific manpower, and your invitation to pinpoint specific areas deserving immediate attention are sincerely appreciated. Few other issues relate so critically to the successful fulfillment of our national aspirations—to the ability of this Nation to maintain our national security, to stimulate economic growth and to continue the march toward a world free of want and of war—as does the development of our human resources. Many vital commitments have already been made which depend upon contributions of science and technology. Meeting these commitments thus depends heavily on an adequate supply of scientists and engineers—adequate in both quantity and quality. Yet, while the abundance of these resources has been the concern of all sectors of our technological community, the formulation of plans to meet the aggregate needs has been the primary responsibility of none. It is for this reason that the President last year asked for an extensive special study of this area, a matter I shall refer to in detail subsequently.

The manyfold demands for technical manpower draw on the same pool of talent—for defense and space, for innovation of civilian products able to compete in a world market, for meeting such domestic problems as mass transportation and environmental pollution associated with a rapidly urbanized society, for medical advancement, and for the effective management of our resources in such a way that we can help upgrade the way of life of citizens throughout the world without downgrading our own. Superposed on these requirements is the need for science, mathematics and engineering teachers to meet the rapidly growing college enrollment. A sharp competition for manpower has resulted, particularly for the superior individual having advanced training. In that competition, not all sectors of demand have succeeded in meeting their needs, and the future outlook is not encouraging.

For the first time, we are confronted with a plurality of goals that may well outstrip our technical manpower resources.

Most of these major goals should not be placed on an either-or basis. Thus, we cannot, in fact we need not, accept the hazards and risks of a random development of our manpower resources to meet present goals. Moreover, the future is difficult to foresee, and we must be prepared to capitalize on the unforeseen; we must be prepared to move as swiftly to exploit new opportunities as we have in space and earlier in atomic energy. Because of the long lead time in training, we cannot do this unless we have a cadre of able, well-trained people.

The Soviet Union's response to this same challenge is well known. They have embarked on a program to improve their capabilities by deliberately training very large numbers of science-oriented professional and semiprofessional personnel. They now graduate, for example, over twice as many baccalaureates in engineering each year as we. Far more significant in my own mind, they already have three times as many Ph. D. engineers in their manpower pool as we—26,000 as compared to our 9,000. The quality of these Soviet resources as measured by talent and high training leaves no room for complacency.

Faced with the same manpower problem as the Soviet Union, how, in a democratic society where each citizen must have a free choice of his or her occupation, do we meet this challenge?

About 1 year ago the President requested that his Science Advisory Committee take stock of our manpower resources and report on measures which should be taken within and without Government to meet our society's complex needs. The Committee's first report, released last December, is one of a series now under preparation, and concentrates on an especially urgent problem of impending shortages of engineers, mathematicians, and physical scientists who combine high ability and advanced training. Based on the Committee's recommendations for action, the President has included in his budget for fiscal year 1964 and in legislation now before the Congress a far-reaching program specifically focused on meeting this shortage. By linking Federal, State, and private efforts, this program would help immediately increase the number already in college—who have made this career choice and who are found qualified—to go on to graduate training.

The urgent need for more individuals having advanced training is clear. The variety and complexity of fundamentals that underpin scientific research have grown enormously. Many fields now embrace two or more disciplines, and require a thorough grounding in each.

Similarly, engineers are called upon to use more sophisticated scientific concepts in the design of military and space systems which, in turn, manifest unprecedented demands for reliability, and economy. Civilian industry, which faces tasks such as the development of natural resources and the improvement of transport systems, must also advance by converting new scientific knowledge to technology, and for this purpose requires men who can draw upon understanding in fields of management, economics, law, behavioral sciences and natural sciences, as well as engineering. Research and engineering activities, whether pursued in the office, classroom, or laboratory, today require training well beyond that afforded in the 4-year undergraduate curriculum.

That even 1 year beyond the baccalaureate significantly strengthens the individual's capabilities is revealed by the large number of students now enrolled in part-time graduate study. In fact, over half of the graduate students in engineering are part time. As valuable as this part-time training may be, full-time attendance would be much better.

To keep pace with our national needs, it is the judgment of the President's Science Advisory Committee that we should and could increase the number of Ph. D.'s each year in engineering, mathematics, and physical sciences (EMP) to reach 7,500 in 1970, the number of master's or equivalent to 30,000. This annual production of 37,500 advanced degrees by 1970 should be compared with 15,000 in 1960, 11,000 in 1950.

A substantial fraction of these new graduates, incidently, must be plowed back into the universities for teaching, and soon. The first wave of the postwar baby boom is already in high school and will move into the universities in 1965. Based on census statistics, the number of eligible college applicants will rise in just 1 year by over 20 percent. Faculty will be required to teach college majors in science, engineering, and mathematics. Additional graduates with specialized training will be needed for high quality teaching in colleges and high schools of future citizens who will work in non-technical fields, but who must be more literate in science if they are to conduct their own affairs and perform public duties intelligently.

At the same time that the college-age population is growing, a larger fraction are entering college. We surely do not want to reverse this trend toward wider educational opportunity. In view of the time required to complete the graduate education necessary for teaching, we are dangerously near the deadline imposed by the unrelenting advance of new college enrollees. It is a little startling to realize that an upper limit to the 1970 crop of technical Ph. D.'s has already been established, since most of these are college juniors.

Parenthetically, the crop for 1980 is also probably limited by quality of math and science courses being taught today to our junior high school students.

It is my view that the baccalaureate base for increased graduate enrollment in engineering, mathematics, and physical sciences is ample to meet PSAC's 1970 goals.

In these three fields, roughly 8 percent of those with a bachelor's degree now go on to a doctorate. We believe that many more are both able and motivated. In fact, in physics and chemistry nearly 20 percent continue on to receive a doctorate. But in engineering, it is only 4 percent; in mathematics, 8 percent. To the Committee, enhancing our manpower supply is primarily a matter of quality not quantity; not a matter of diverting more college students to science and engineering, but of providing for more students who have chosen this career route the opportunity to continue their studies. This means, first, sharply increasing the fraction of full-time students who go on to graduate study in mathematics and engineering and second, with numerically increasing enrollments in physics and chemistry, assuring continuation of at least the same fraction who complete the doctorate.

Assuming that the proportion of baccalaureates in these three fields continues unchanged in relation to the total number of bachelors degrees (somewhere around 17 percent), the actual number of graduates will approximately double during this decade because of increased total enrollments. With 3,000 doctorates produced in 1960, a potential of 6,000 for 1970 is a minimum expectation. However, we have already noted that the fraction of engineers and mathematicians who now go on to the doctorate is far less than in other fields of science, and could be markedly increased without any drop in academic standards. This explains then, the 7,500 goal for 1970 rather than 6,000. Neither of these, however, will be realized unless significant steps are taken immediately to increase the opportunities for the students and the capacity of the institutions.

With regard to students, the major barrier to continuation of full-time graduate study is financial. Faced with a choice of a starting salary above $7,000, and a very much smaller stipend for graduate study, many highly qualified college graduates—especially those with family responsibilities and those who incurred debts as undergraduates— decide that they cannot afford graduate education. Others extend their study by combining part-time study with part-time work, often becoming a dropout.

Another barrier is inadequate graduate facilities. Increasingly, universities will be obliged to turn away students because of space or faculty limitations.

In addition, there is very convincing evidence that some geographical areas produce a much greater proportion of doctorates than others. In fact, 10 States are producing doctoral graduates at a rate nearly three times that of the remaining 40 States. Relatively few students are prepared to study more than several hundred miles from their homes. It would thus appear that we have a special problem in terms of meeting an unequal geographical distribution of centers of educational excellence.

The present barriers to graduate education—limitations in student support, number of faculty, and educational facilities—must be overcome. It is to that end that the President has proposed that the Federal Government take the initiative and provide the leadership needed to meet these national needs.

To meet goals for graduate education in the three fields of potential shortage—engineering, mathematics, and physical sciences—it is of critical importance that we increase the number of graduate students enrolling in the fall of 1964 from the 22,000 which may be expected on the basis of projected trends to some 30,000. The number of full-time graduate students should also be increased. Therefore, the President has proposed support for 12,000 qualified first year enrollees and for 14,000 graduate students beyond the first year of their training. These numbers should be compared to support for roughly 3,500 first year and 10,000 advanced graduate students in 1962. Emphasis, you will note, is on the number of new starts. Support would be provided within existing legislation, through NSF, AEC, and NASA fellowships, and through new NSF science development and training grant programs. Support would also be provided for research assistantships in accordance with present patterns. The President has also proposed that the NDEA fellowship program, which has been eminently successful, be extended and considerably expanded in H.R. 3000 now before the Congress, especially to accommodate increasing enrollments in these three fields. In virtually all of these cases, assistance to students would be accompanied by a grant directly to the college or university to help meet the true cost of education, and thus would assist the university to maintain an internal balance between fields.

The President also proposes Federal support for new physical facilities, including funds through NSF laboratory and science development grants, through NASA university grants and through a new program proposed in H.R. 3000, of graduate facilities to be operated by the Office of Education. These amounts total some $85 million, as compared to $24 million in 1962. Virtually all of these facilities funds would be on a 50–50 matching basis. Further details are given in an enclosed table.

The proposed program is designed to achieve a substantial and unprecedented acceleration in the rate of production in advanced degrees in these three fields. The proposition that the Federal Government should increase its responsibilities in this area is supported by three arguments: (a) the Federal Government supports almost three-fourths of all research and development conducted in this country, including major expenditures for space and military activities, and it is these programs of Federal origin that have created the shortage; (b) State governments and privately endowed universities face practical difficulties in raising the funds required for expansion in graduate education, especially in competition with funds that will be needed to meet the undergraduate surge; (c) because the demand for specialized manpower is nationwide, neither States nor communities feel it their exclusive responsibility to meet problems or contribute funds which, in the case of graduate education, may primarily benefit the economy of other communities or other States.

There is nothing completely new about Federal assistance for higher education. Past experience with the GI bill and the National Defense Education Act program, Federal agency supported mission-oriented research, and NSF-sponsored basic research, on the whole, has been eminently successful. What is new about the President's program, however, is an acceptance by the Federal Government of a Nation's responsibility to assure the adequacy of technical manpower resources to meet its commitments—by providing more and better opportunities for advanced training.

In this letter, it has been possible to convey only a few highlights of this very complex problem concerned with the supply and demand of specialized manpower. The ills are difficult to diagnose; prescriptions often uncertain in effect. I have wanted to respond to your very kind invitation, however, by bringing to your attention the findings of studies already completed for the President and of the important proposals which are now before the Congress to meet impending shortages in engineering, mathematics, and physical sciences. Our studies are continuing incidentally in relation to other problem areas.

The technical fields in which these manpower are engaged relate to the missions of a number of different Federal agencies. Moreover, the support for graduate education and research is involved in the budgets of a number of agencies. The problem, therefore, covers a broad spectrum of interest. I would certainly agree with your suggestion, and I am sure the President would be pleased if your committee would provide a forum to explore full implications of the technical manpower problem, as well as the possible consequences of delay and inattention to this issue.

Sincerely,

JEROME B. WIESNER.

APPENDIX C

A LIST OF MAJOR PROJECTS SUPPORTED UNDER THE COURSE CONTENT IMPROVEMENT PROGRAM

As Reported to the House Committee on Appropriations in Hearings
During March 1964

A LIST OF MAJOR PROJECTS SUPPORTED UNDER THE COURSE CONTENT IMPROVEMENT PROGRAM

The amount listed for each heading is the total obligated as of February 29, 1964. Under each heading is listed the title of the project, the grantee institution, the total amount obligated for each project and a brief statement of activities. The list is not complete. It is intended to give a quantitative picture of the output of the major study groups.

ELEMENTARY AND JUNIOR HIGH SCHOOL STUDIES, $8,992,400

Elementary science $4,577,606

1. *Commission on Science Education, American Association for the Advancement of Science, $940,260.*—A national planning and coordinating group for elementary science projects. The group is also developing instructional materials for kindergarten through the sixth grade. Preliminatory materials under school trial in 1963–64.

2. *Elementary school science curriculum project, Educational Services, Inc., $1,768,590.*—The development of kits of materials including teachers' guides, bibliographic material, film loops and apparatus for units suitable for use in elementary school science courses. Five units will be available commercially in the fall of 1964 and development and school trials and continuing on eight additional units.

3. *Elementary school and junior high school science education, University of Illinois, $228,200.*—A complete science program for elementary and junior high school, with emphasis on sequential relationships. Preliminatory materials written in the summer of 1963 and now under trial in the schools cover such topics as the growth of plants, force and motion, animal behavior, and water, earth, and air.

4. *Science and mathematics curriculum for grades K–9, University of Minnesota, $405,560.*—A sequential coordinated science and mathematics curriculum, accompanied by text materials for the preparation of teachers. Preliminary editions of mathematics materials for kindergarten through third grade and sample units of science materials for grades 1 to 8 are being tested in trial centers throughout the United States.

5. *Elementary school science project, University of California (Berkeley), $311,000.*—The original aim of the project was to prepare a scientifically and psychologically sound program. A main idea of the project was research into what children could and could not learn. Several papers on the observations have been published in scholarly journals. More recently attention has centered on completion of units of science materials for the elementary grades. A number of units have been published in preliminary form, including coordinates, several in human physiology, botany, animal coloration, chemical properties and reactions, and genetics.

6. *Elementary school science course content improvement project, University of Illinois, $359,900.*—A program centered on astronomy as an introduction to physical science in grades 5 to 8. Two units, "Charting the Universe" and "The Universe in Motion" are virtually finished. "Gravitation" is being tested before final revision. Three other units are in preliminary form.

7. *Junior high school science project, Princeton University, $223,700.*—A junior high school course in physical science. Students concentrate on laboratory work; textual materials are written for the teacher. Revised edition of 1-year course is under trial. Experimental trials in selected special situations are anticipated.

Elementary and junior high school mathematics, $4,414,794

1. *School mathematics study groups, Stanford University, $2,624,580.*—Twenty-five volumes for the fourth to the eighth grade are available in paperback format from the Yale University Press and from A. C. Vroman, Inc. These include textbooks and teachers' commentaries, units to use in existing courses, supplementary units for gifted students, and studies in mathematics for teachers.

Textbooks and teachers' commentaries for kindergarten through the third grade are nearing completion. A series of 30 half-hour color films entitled, "A Brief Course in Mathematics for Elementary School Teachers," and a text to accompany the films is available.

2. *University of Illinois Committee on School Mathematics, University of Illinois, $757,820.*—Preliminary seventh grade course materials oriented toward the applications of mathematics have been written and are undergoing trial in schools prior to revision. Eighth-grade materials being written will continue the sequence. The aim is to complete first-year algebra by the end of grade 8 to leave room for a 12th-grade course in calculus.

3. *The Madison project, Webster College, $257,700.*—Eighteen finished films and additional footage for several more have been produced suitable for preservice and inservice mathematics training of elementary and secondary school teachers. These films and accompanying text materials are in use in over 60 colleges and universities in 43 States and are frequently used for teachers' workshops and professional meetings.

4. *Experimental teaching of mathematics in the elementary schools, Stanford University, $518,430.*—The project is developing and testing a 3-year sequence for gifted primary school children, materials for kindergarten, and texts in mathematical logic for grades 5 and 6. Four 22-minute films have been produced to demonstrate to teachers useful techniques in presenting mathematical concepts to children.

SECONDARY SCHOOL STUDIES, $25,032,000

Biology.—The Biological Sciences Curriculum Study (BSCS), University of Colorado, $7,198,620, has produced three versions of biology course materials for high schools which became available for schools in the fall of 1963. These courses include textbooks, teachers' handbooks, achievement tests for each version, 4 laboratory blocks for 6 weeks of intensive laboratory work, a laboratory techniques book, a book of investigations for gifted students, a pamphlet series on supplementary topics; in all, 14 volumes, plus the tests and pamphlets. In preparation are a textbook for an advanced course, text materials for slow students, a set of short single-concept films, and a special publication series concerned with teacher preparation.

Chemistry.—Two integrated sets of course materials for high school chemistry became available for school use in the fall of 1963. The chemical bond approach project (CBAP), Earlham College, $1,231,485, has produced a textbook, a teacher's guide, a set of laboratory experiments and laboratory manual, and two volumes of supplementary readings for teachers and students.

The Chemical Education Material Study (Chems), University of California (Berkeley), $2,654,510, has produced a textbook, a teacher's guide, a set of laboratory experiments and a laboratory manual, a set of achievement examinations, two programed instruction pamphlets and a set of twenty-six 20-minute supplementary films.

Physics.—The Physical Science Study Committee (PSSC), Educational Services Inc., $5,701,083, has produced a set of instructional materials, available in commercial form in 1960. The set includes a textbook, laboratory equipment in kit form and a laboratory manual, achievement tests for the course, a set of fifty-three 20- to 30-minute supplementary films (also useful at the introductory college level) and accompanying film notes, and a set of 33 paperback books (science study series) on supplementary topics related to the PSSC course. (Over 1,600,000 copies of this series have been sold as of October 1963). Nine more volumes are partially completed. In addition, the PSSC is developing a set of supplementary chapters on advanced topics which together with the textbook will provide an advanced high school course or an elementary college course.

Earth Sciences.—The earth sciences curriculum project (ESCP)—American Geological Institute, $731,522, is constructing a ninth-grade course in earth science. Outlines were developed in 1963 and will be used as starting material by a 1964 writing conference. In addition to a text, a pamphlet series, laboratory equipment, films, and teacher preparation materials are anticipated.

Mathematics.—School mathematics study group (SMSG)—Stanford University, $6,192,300. Thirty-three volumes for grades 9 through 12 are now available in definitive versions. These include textbooks and teachers' commentaries, studies in mathematics for teachers, and a paperback monograph series for students and teachers. Under development are a ninth-grade integrated mathematics science course and texts for the following courses taught increasingly at the high school level: calculus, analytic geometry, and computer mathematics.

The University of Illinois Committee on School Mathematics (UICSM)—University of Illinois, $701,850. Text materials are being developed for grades 9 through 11. Grade nine will continue a study of algebra and informal geometry; a vector geometry course for grades 10 through 11 has been completed in a preliminary version and is being tried out in schools prior to a definitive edition. A film course (49 half-hour films and accompanying text materials) in algebra for training ninth-grade teachers has been produced and will be made available in the near future.

College and university studies

Agriculture

Committee on Educational Policy in Agriculture (CEPA), *National Academy of Sciences, NRC, $114,030.*—This group reviews trends in education in the agricultural sciences and is preparing guidelines for developing undergraduate curricula in agriculture.

Anthropology

American Indian films, University of California, Berkeley, $360,400.—This project has for its purpose the recording of the arts, crafts, ceremonies, and rituals of the Indian tribes of Western America in color motion pictures. These records of such rapidly vanishing customs will be most useful in research and teaching in many disciplines in addition to anthropology. Eleven films are now available. Shooting has been completed on twenty-five others and a similar number are in earlier stages of production.

Biological sciences

Commission on Undergraduate Education in the Biological Sciences (CUEBS), *University of Washington (St. Louis), $195,650.*—This is an independent body of 22 college and university biologists interested in the improvement of biology teaching in undergraduate programs. This is a relatively new group, but it has already identified certain areas of interest, including preparation of future biology teachers, advanced undergraduate biology curriculums, and biology background for the nonbiologist.

Chemistry

Films for general college chemistry, Yale University, $150,000.—Most of these films are quite short. Although sound tracks are provided, the teacher can readily turn off the sound and interpret the visual material to the students according to his own views. Representative titles include: Handling Chemicals-Solids"; "Air-Damped Analytical Balance"; "Sulfur, Electronegativity"; "Electrolysis of Water"; "Slow Reaction (Iron and Oxygen)."

Advisory Council on College Chemistry (ACCC), *University of Pennsylvania, $48,280.*—The objective of this project is a professionwide effort to stimulate and provide coordination among a number of independent efforts to improve undergraduate instruction in chemistry and to facilitate communication on the importance of good teaching ideas in this field. The Council has working panels active in the following areas: recommendations for the general college chemistry curriculum; consideration of promising new approaches in upper division chemistry courses; training of prospective chemistry teachers; preparation of teaching aids such as "Resource Letters," bibliographies, film directories, library lists, listings of recent laboratory construction (with recommended references and design consultants) and useful charts, models and demonstration equipment.

Earth sciences

Geological education orientation study (GEO-study), *American Geological Institute, $176,240.*—The objectives of GEO-study are to analyze the present status of education in the geological sciences, to identify significant trends and develop new ideas and concepts for the improvement of education in geology, and to bring about the broadest possible involvement of the geological profession in curriculum reform.

Engineering

Commission on Engineering Education (CEE), *Educational Services Inc., $148,967.*—This group, has the objective of developing and maintaining engineering education at a maximum level of excellence. Its program is designed to improve the effectiveness of engineering education by increasing the capabilities of individual faculty members, providing educational resources, and developing a thorough understanding of factors affecting the motivation and accomplishment of engineering students.

Undergraduate courses in discrete-state system theory, Polytechnic Institute of Brooklyn, $202,980.—The broad objective is to develop teaching materials for the introduction of discrete-state system concepts at appropriate places at each year of undergraduate education. Mathematics and engineering departments at Carnegie Institute of Technology, Case Institute of Technology, Illinois Institute of Technology, Polytechnic Institute of Brooklyn, and Rensselaer Polytechnic Institute are participating in this development.

Goals of engineering education, American Society for Engineering Education, $202,645.—The specific aim of this project is to determine what is required in the education of an engineer to enable him to serve the needs and meet the responsibilities of the engineering profession over the next quarter to half century. A detailed report will be prepared to assist those responsible for the design and operation of engineering educational programs and it is anticipated that accreditation groups will find the recommendations helpful in setting forth accreditation objectives and procedures.

Semiconductor electronics education committee (SEEC), Educational Services Inc., $260,200.—This group is made up of representatives of 16 academic and 8 industrial organizations who are working together to improve the undergraduate teaching of semiconductor physics devices and circuit applications. The committee is preparing a course which emphasizes the special relationships between physical properties of semiconductor components and their circuit applications with attention to the corresponding special advantages and limitations. Trial editions of seven paperback texts and two films have been prepared to date. Texts include: Introduction to Semiconductor Physics, Physical Electronics and Circuit Models of Transistors, Elementary Circuit Properties of Transistors, Characteristics and Limitations of Transistors, Multistage Transistor Circuits, Studies in Digital Transistor Circuits, and Transistor Circuit Handbook. The films are: Gap Energy and Recombination Light in Germanium and Minority Carriers in Semiconductors.

Engineering education development program, Michigan State University, $240,700.—The project is concerned with the development of a new instructional program in electrical engineering. Representatives of some 30 universities held a study session the summer of 1963. Future conferences are planned. Trial classes are being conducted at Michigan State University. Now available as reports are parts I and II of Analysis of Discrete Physical Systems.

Demonstration-experiment films in fluid mechanics, Educational Services Inc., $1,183,000.—The National Committee for Fluid Mechanics Films, which has nationwide representation from nine universities, is producing motion pictures which will make it possible for students to receive more effective instruction in fluid mechanics than is possible from words and formulas from the textbook and the lecturer. Approximately 25 major films and as many as 200 short film loops will be prepared. Five films and a number of film loops are currently available. The five films are: "Fluid Dynamics of Drag," "Vorticity," "Flow Visualization," "Deformation of Continuous Media," and "Pressure Fields and Fluid Acceleration." Two additional films will be released shortly, "Surface Tension" and "Waves in Fluids"; work is well underway on six more.

Electrical engineering films, Educational Services, Inc., $200,200.—Preliminary work on the production of three films to clarify difficult and abstract concepts in electrical engineering has been initiated. The films will make considerable use of animation.

Mathematics

Committee on the Undergraduate Program in Mathematics (CUPM), Mathematical Association of America, $1,558,120.—The Committee on the Undergraduate Program in Mathematics is concerned with the system consisting of the undergraduate curriculum in mathematics, the students and their teachers, the purposes of the program, its achievements and shortcomings, and facilities for undergraduate mathematics. The principal work is partitioned into four areas represented by panels. These are: (1) training of elementary and secondary schoolteachers, (2) mathematics for students of physical and engineering sciences, (3) mathematics for the biological, management, and social sciences, and (4) the pregraduate education of potential research mathematicians. The panels have produced booklets and course outlines presenting recommended modern curricula in college-level mathematics in these four areas. These have been circulated to colleges and universities, to mathematicians, and to engineers, scientists, and scholars in the pertinent disciplines. In addition CUPM has (1) stimulated projects for the development of a number of textbooks needed for the recommended programs, (2) administered a number of conferences of scholars in appropriate disciplines during the development of the booklets, for the discussion of proposed recommendations, (3) administered conferences in 22 States for discussion and recommendations on the implementation of mathematics teacher-training programs (similar conferences in other States are planned), (4) maintained a consultant's bureau of mathematics scholars, which has assisted colleges in 34 States and the District of Columbia in the improvement of their mathematics curricula, (5) collected materials for booklets on applications of mathematics to problems in engineering, and (6) developed a recommended basic list of books and journals for mathematics libraries.

Geometry course for prospective high school mathematics teachers, University of Minnesota, $320,970.—The principal objective is the preparation of a 1-year college geometry course for the training of prospective high school teachers, with the intent of exploring the various educational media and selecting those most appropriate for a given topic at each stage of the course. Those portions of the course that must lend themselves to visual techniques will be prepared on film. It is estimated that 50 to 70 short, animated or partially animated films will be produced.

Physics

Commission on College Physics (*CCP*), *Bryn Mawr College, $625,260.*—This independent group of 17 physicists was established by the American Association of Physics Teachers for the Improvement of Undergraduate Instruction in Physics. Recognizing that this improvement can be made only by physics departments and physics teachers, the Commission considers that the major action toward its objectives should be taken by universities, colleges, and professional physics organizations. Its major function is to stimulate and coordinate needed activities for the improvement and modernization of physics. Among these activities are (1) a series of four conferences culminating in recommendations for modern college physics curricula for (*a*) physics majors and (*b*) scientists, mathematicians and others, (2) regional conferences for discussion and implementation of the recommended curricula, (3) a national conference of scientists, teachers and school administrators (jointly with the Advisory Council on College Chemistry) on the development of a physical science course for prospective elementary teachers and nonscientists, (4) preparation of outlines and resource materials for courses in plasma physics and nuclear physics, (5 the development of a series of paperback physics monographs at the college level (5) now available as "Momentum Books" from Van Nostrand; 17 under contract), (6) a set of "Resource Letters" providing bibliographical references, editorial comment on their use and lists of films and apparatus, for topics not readily available to the teacher (6 letters have been published and 10 additional units are underway, (7) cooperation with the college film project described elsewhere, (8) organization of a conference on the use of inexpensive high vacuum techniques for undergraduate instruction, and (9) the organization of summer conferences for college teachers (four in 1963, five to be held in 1964).

Films for college and university physics courses, Educational Services Inc., $614,050.—The purpose of this project is to provide high quality films of demonstrations and experiments for college and university level physics courses. Materials such as films notes, journal articles, graphs, photographs, and slides are also provided, where appropriate, for each film. Nine 30-minute (approximate) films have been produced and about fifteen shorter films are also available. The nine films now available are: The Size of Atoms from an Atomic Beam Experiment, Angular Momentum, The Ultimate Speed, Time Dilation, Momentum of Electrons, Reflection and Refraction, Interference and Diffraction, Barrier Penetration-Bragg Reflection-Doppler Effect, and Solder Glass Technique.

Science Teaching Center, Massachusetts Institute of Technology, $396,000.—The Science Teaching Center is concerned with the first 2 years of college physics and is now preparing a new introductory course. The lecture material will be concerned specifically with relativity and quantum physics. Student laboratory experiments and lecture and corricor demonstrations are also being prepared. The Center also assists in the production of films for college physics courses.

Berkeley physics course and laboratory, Educational Services, Inc., $429,210.—This is a 2-year elementary college physics course for students majoring in science and engineering. The intention is to present elementary physics as far as possible in a way in which it is used by physicists working on the forefront of the field and to strongly reflect the revolutions in physics of the last hundred years.

Psychology

Film series on scientific developments in psychology, American Psychological Association, $365,410.—The film programs in psychology present current research in experimental psychology which reveal significant concepts, methods, and new advances in the scientific study of behavior. Ten films, each approximately 30 minutes long, have been produced. The series will be shown on more than 70 educational television stations. By title, the 10 films are: "The Conscience of a Child." "A World to Perceive." "The Brain and Behavior," "The Chemistry of Behavior," "Learing About Learning," "No Two Alike," "The Social Animal," "The Need To Achieve," "Of Man and Machines," and "Computers and Human Behavior."

A List of Published Instructional Materials (Not Including Experimental Versions) Developed With Financial Support of the National Science Foundation

This list was compiled to answer questions frequently asked about such instructional materials, especially those for us in elementary and secondary schools. Inclusion of an item carries no implication of endorsement or approval of it by the Foundation. The list is limited largely to definitive versions of printed materials (textbooks, laboratory guides, teachers' guides, supplementary readings) now available to any who wish to obtain them Preliminary experimental versions, special reports, films, other audiovisual aids, and equipment are not listed here.

Biological Sciences Curriculum Study (BSCS):

- Blue Version—*Biological Science: Molecules to Man*, Houghton Mifflin Co., 2 Park St., Boston, Mass. 02701. (Molecular and evolutionary approach.)
- Green Version—*High School Biology, BSCS Green Version*, Rand, McNally Co., P.O. Box 7600, Chicago, Ill. 60680. (Ecological and evolutionary approach.)
- Yellow Version—*Biological Science: An Inquiry Into Life*, Harcourt, Brace & World Co., 757 Third Ave., New York, N.Y. 10017. (General and cellular approach.)
- *BSCS Version Quarterly Tests* (version publishers).
- *BSCS Comprehensive Final Exam*, Psychological Corp., 304 E. 45th St., New York, N.Y. 10017.
- Laboratory Blocks, D.C. Heath and Co., 285 Columbus Ave., Boston, Mass. 02116.
  - *Plant Growth and Development*
  - *Animal Growth and Development*
  - *Microbes: Their Growth, Nutrition and Interaction*
  - *Interdependence of Structure and Function*
- *Innovations in Equipment and Techniques for the Biology Teaching Laboratory*, D.C. Heath and Co.
- *Biology Teacher's Handbook*, John Wiley & Sons, Inc., 605 Third Ave., New York, N.Y. 10016.
- *Research Problems in Biology: Investigations for Students*, Series One and Series Two, Doubleday & Co., Inc., 501 Franklin Ave., Garden City, N.Y. 11530.
- BSCS Pamphlet Series D. C. Heath and Co. (9 titles; more coming).
- BSCS Bulletin Series, BSCS, University of Colorado, Boulder, Colo. 80304.
  - *Biological Education in American Secondary Schools, 1890–1960* (Hurd).
  - *Teaching High School Biology: A Guide to Working with Potential Biologists* (Brandwein-Metzner-Morholt-Roe-Rosen).
- BSCS Special Publication Series, BSCS.
  - *BSCS Biology Guidelines for Preparation of In-Service Teachers* (Klinckmann).
  - *Patterns for the Preparation of BSCS Biology Teachers* (Cox).

Chemical Bond Approach Project (CBA):

- *Chemical Systems*, McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N.Y. 10036; also Teacher's Guide.
- *Investigating Chemical Systems* (McGraw-Hill); also Teacher's Guide.
- *Supplementary Readings for Chemical Bond Approach, Reprinted from Scientific American*, W. H. Freeman and Co., 660 Market St., San Francisco, Calif. 94104.
- *Supplementary Readings for Chemical Bond Approach, Reprinted from Journal of Chemical Education*, Chemical Education Publ. Co., 20th and Northampton Sts., Easton, Pa. 18042.

- Chemical Education Materials Study (CHEMS):
  - From: W. H. Freeman and Co. CHEMStudy, 660 Market St., San Francisco, Calif. 94104.
    - *Chemistry: An Experimental Science.*
    - Laboratory Manual: *Chemistry: An Experimental Science.*
    - *Teachers Guide for Chemistry: An Experimental Science,* 2 vol.
    - *CHEM Study Achievement Examinations.*
    - Programmed Instruction Pamphlets: *Use of Exponential Notation, Use of the Slide Rule.*
- Physical Sciences Study Committee (PSSC):
  - *Physics,* D. C. Heath and Co.
  - *P.S.S.C. Physics, Teacher's Resource Book,* Parts 1, 2, 3, 4, D. C. Heath and Co.
  - *Physics Laboratory Guide,* D. C. Heath and Co.
  - *Tests of the Physical Sciences Study Committee,* Educational Testing Service, Princeton N.J. 08540.
  - *Teacher's Guide to the PSSC Films,* Modern Learning Aids, 3 East 54th St., New York, N.Y. 10022.
  - Science Study Series, paperback books (over 30 titles), Doubleday and Co., Inc.
- School Mathematics Study Group (SMSG):
  - Published by Yale University Press, School Mathematics Study Group, 92-A Yale Station, New Haven, Conn. 06520. Each item includes a Student Text and a Teacher's Commentary:
    - *Mathematics for the Elementary School,* separate for Grade 4, Grade 5, Grade 6.
    - *Mathematics for Junior High School,* vol. 1 and 2.
    - *Introduction to Secondary School Mathematics,* vol. 1 and vol. 2.
    - *Introduction to Algebra.*
    - *First Course in Algebra.*
    - *Geometry.*
    - *Geometry with Coordinates.*
    - *Intermediate Mathematics.*
    - *Elementary Functions.*
    - *Introduction to Matrix Algebra.*
  - From A. C. Vroman, Inc., 367 South Pasadena Ave., Pasadena, Calif. 91105:
    - Studies in Mathematics (for teachers).
      - *Euclidean Geometry Based on Ruler and Protractor Axioms.*
      - *Structure of Elementary Algebra.*
      - *Geometry.*
      - *Concepts of Informal Geometry.*
      - *Number Systems.*
      - *Intuitive Geometry.*
      - *Concepts of Algebra.*
    - Conference Reports.
      - *Conference on Elementary School Mathematics.*
      - *Orientation Conference for SMSG Experimental Centers.*
      - *Orientation Conference for SMSG Elementary School Experimental Centers.*
      - *Orientation Conference for Geometry with Coordinates.*
      - *Conference on Future Responsibilities for School Mathematics.*
    - Junior High School Mathematics Units.
      - *Number Systems.*
      - *Geometry* (separate text and commentary).
      - *Applications* (separate text and commentary).
    - Study Guides in Mathematics (for teachers).
    - Supplementary Units.
      - *Junior High School Supplementary Unit* (separate text and commentary).
      - *Essays on Number Theory,* I and II.
      - *Development of the Real Number System.*
    - Spanish Translations.
      - *Matemáticas para el Primer Ciclo Secundario,* vol. 1.
      - *Matemáticas para el Primer Ciclo Secundario,* vol. 2.
      - *Matemática para la Escula Secundaria, Primer Curso de Algebra.*
      - *Matemática para la Escula Secundaria, Geometria.*

New Mathematical Library, L. W. Singer Co., Inc., 249–259 West Erie Blvd., Syracuse, N.Y., 13202.

- *Numbers—Rational and Irrational* (Niven).
- *What is Calculus About?* (Sawyer).
- *An Introduction to Inequalities* (Beckenback-Bellman).
- *Geometric Inequalities* (Kazarinoff).
- *The Lore of Large Numbers* (Davis).
- *The Contest Problem Book.*
- *Uses of Infinity* (Zippin).
- *Geometric Transformations* (Yaglom-Shields).
- *Continued Fractions* (Olds).
- *Graphs and Their Uses* (Ore).
- *Hungarian Problem Book*, vol. 1 and vol. 2 (Rapaport).

Some other Publications of Interest:

Survey of Recent East European Literature on School and College Mathematics: List of books, pamphlets, etc. (53 titles) available in English translation, Dr. Alfred L. Putnam (project director), Department of Mathematics, University of Chicago, Chicago, Ill., 60637.

American Geological Institute: *Geology and Earth Sciences Sourcebook for Elementary and Secondary Schools*, Holt, Rinehart and Winston, Inc., 383 Madison Ave., New York, N.Y., 10017.

Committee on the Undergraduate Program in Mathematics, Mathematical Association of America, P.O. Box 1024, Berkeley, Calif., 94701.

- *Course Guides for the Training of Teachers of Junior High and High School Mathematics.*
- *Recommendations for the Training of Teachers of Mathematics, A Summary.*

Laboratory and Field Studies in Biology, a Source Book for Secondary Schools, Teacher and student eds., Holt, Rinehart and Winston.

Goals for School Mathematics, the Report of the Cambridge Conference on School Mathematics, Houghton Mifflin Co.

The Teaching of Anthropology (Mandelbaum-Lasker-Albert), University of California Press, Berkeley, Calif., 94720.

Resources for the Teaching of Anthropology (Mandelbaum-Lasker-Albert), University of California Press.

Laboratory Experiments in General Physiology, American Physiological Society, 9550 Wisconsin Ave., Washington, D.C., 20014.

Laboratory Experiments in Elementary Human Physiology, American Physiological Society.

Twenty-Six Afternoons of Biology (Wald-Albersheim-Dowling-Hopkins-Lacks), Addison-Wesley Publ. Co., Inc., Reading, Mass., 01867 (college level).

APPENDIX D

(1) EXECUTIVE ORDER No. 11185: TO FACILITATE COORDINATION OF FEDERAL EDUCATION PROGRAMS. (OCT. 16, 1964, F.R. 14399)

(2) EXECUTIVE ORDER No. 11260 AMENDING EXECUTIVE ORDER No. 11185 RELATING TO FACILITATING COORDINATION OF FEDERAL EDUCATION PROGRAMS. (DEC. 15, 1965, 30 F.R. 15395)

(3) FEDERAL INTERAGENCY COMMITTEE ON EDUCATION: BACKGROUND INFORMATION—SUBMITTED TO THE HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS, SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT IN 1970

[Oct. 16, 1964, 29 F.R. 14399]

Executive Order No. 11185: To Facilitate Coordination of Federal Education Programs

Whereas sound public policy requires a continuing appraisal of the relation of Federal educational activities to the educational needs and goals of the Nation and to its educational systems and institutions; and

Whereas the scope of, and program outlays for, Federal educational activities have been expanded greatly and have a significant influence on education in this country and the American people; and

Whereas many Federal agencies are involved both directly and indirectly in carrying on educational programs either as Federal activities or in cooperation with State and local units of government; and

Whereas closer coordination of Federal educational activities will facilitate the resolution of common problems and otherwise promote effective planning and management of such activities; and

Whereas, under the direction of the Secretary of Health, Education, and Welfare (hereinafter referred to as the Secretary), the Office of Education is directed by law to collect data on the progress of education, provide information to aid in the maintenance of efficient school systems, and otherwise promote the cause of education throughout the country (14 Stat. 434; 20 U.S.C. 1):[1]

Now, Therefore, by virtue of the authority vested in me as President of the United States, it is hereby ordered as follows:

Section 1. Functions of the Secretary of Health, Education, and Welfare. The Secretary, with the assistance of the Commissioner of Education (hereinafter referred to as the Commissioner), shall identify the educational needs and goals of the Nation and from time to time shall recommend to the President policies for promoting the progress of education.

Sec. 2. Functions of the Commissioner of Education. Under the direction of the Secretary, the Commissioner shall:

(a) study the current effects of Federal activities upon the educational programs of State, local and nonprofit educational institutions, assess future trends of such activities, and (taking into consideration the relationship between education and policies in fields such as manpower development, defense, military manpower, economic growth, and science) develop recommendations for educational activities, or for coordination of policies affecting such activities;

(b) exercise leadership in seeking timely resolution of differences of opinion concerning policies or administrative practices with respect to Federal educational activites affecting educational institutions;

(c) make appropriate arrangements for obtaining advice and information, including establishment of ad hoc working groups to consider special problems, and utilizing existing interagency machinery wherever appropriate; and

(d) exercise initiative in obtaining pertinent and consistent data permitting an overview of Federal educational activities.

Sec. 3. Agency responsibilities. The heads of Federal agencies, as to their respective education related programs, shall:

(a) insofar as practicable, take such actions as may be necessary to assure: (1) conformity of their programs with the educational goals and policies of the Nation, as identified by the Secretary, and (2) consistent administrative policies and practices among Federal agencies in the conduct of similar programs:

(b) keep each other fully and currently informed in order to achieve coordinated planning and prevent unnecessary duplication of activities:

(c) provide information requested by the Secretary or the Commissioner on educational matters; and

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[1] 20 U.S.C.A. § 1.

(d) cooperate with the Secretary and the Commissioner in the conduct of such studies and analyses as may be necessary to carry out the responsibilities and duties assigned by this order. To this end the heads of Federal agencies shall maintain information on current and planned activities that can readily be analyzed in conjunction with information on related activities of other Federal agencies.

SEC. 4. Establishment and functions of a Federal Interagency Committee on Education. (a) There is hereby established a "Federal Interagency Committee on Education" (hereinafter referred to as the "Committee").

(b) The Committee shall advise the Secretary, the Commissioner, and the heads of Federal agencies in connection with the responsibilities assigned to them by this order.

(c) The Committee shall be composed of the Commissioner, who shall be the chairman, and one appropriate representative of each of the following: the Department of State, the Department of Defense, the Department of Agriculture, the Department of Labor, the National Science Foundation, the Atomic Energy Commission, and the National Aeronautics and Space Administration.

(d) The chairman may invite Federal agencies additional to those which are represented on the Committee under the provisions of subsection (c), above, to designate representatives to participate in meetings of the Committee on matters of substantial interest to such agencies which are to be considered by the Committee.

(e) The Director of the Bureau of the Budget, the Chairman of the Council of Economic Advisers, and the Director of the Office of Science and Technology may each designate a member of his staff to attend meetings of the Committee as an observer.

(f) Each Federal agency which is represented on the Committee under the provisions of subsection (c), above, including the Department of Health, Education, and Welfare, shall furnish necessary assistance to the Committee in accordance with Section 214 of the Act of May 3, 1945, 59 Stat. 134 (31 U.S.C. 691).[1]

SEC. 5. Construction. Nothing in this order shall be construed as subjecting any Federal agency, or any function vested by law in, or assigned pursuant to law to, any Federal agency, to the authority of any other Federal agency, or as abrogating or restricting any such function in any manner.

SEC. 6. Definition. Except as may be inconsistent with the provisions of this order or otherwise inappropriate, the term "Federal agency", as used herein, includes any department or other agency or instrumentality (including officers) of the executive branch of the Government of the United States.

LYNDON B. JOHNSON.

THE WHITE HOUSE, *October 16, 1964.*

[Dec. 15, 1965, 30 F.R. 15805]

EXECUTIVE ORDER NO. 11260 AMENDING EXECUTIVE ORDER NO. 11185 RELATING TO FACILITATING COORDINATION OF FEDERAL EDUCATION PROGRAMS

Whereas there has been created in the Department of Health, Education, and Welfare, under the authority of Section 4(a) of Public Law 89–115, approved August 9, 1965, 79 Stat. 449,[2] the position of "Assistant Secretary (for Education)"; and

Whereas it is appropriate that the Assistant Secretary (for Education) perform the function of facilitating the coordination of Federal education programs and be a member, and the chairman, of the Federal Interagency Committee on Education:

Now, therefore, by virtue of the authority vested in me as President of the United States, it is ordered that Executive Order No. 1185[3] of October 16, 1964, entitled "To Facilitate Coordination of Federal Education Programs," be, and it is hereby, amended as follows:

(1) By substituting for the text "Commissioner of Education (hereinafter referred to as the Commissioner)" in Section 1 the following: "Assistant Secretary (for Education) (hereinafter referred to as the Assistant Secretary)".

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[1] 31 U.S.C.A. § 691.
[2] 5 U.S.C.A. § 623h.
[3] 20 U.S.C.A. § 1 note.

(2) By substituting for "Commissioner of Education" in the catchline of Section 2 the following: "Assistant Secretary (for Education)".

(3) By substituting for the word "Commissioner" in the first sentence of Section 2 and in Sections 3(c), 3(d), and 4(b) the words "Assistant Secretary".

(4) By substituting for the text "The Committee shall be composed of the Commissioner, who shall be the chairman", in Section 4(c), the following: "The Committee shall be composed of the Assistant Secretary, who shall be the chairman, the Commissioner of Education".

LYNDON B. JOHNSON.

THE WHITE HOUSE, *December 11, 1965.*

FEDERAL INTERAGENCY COMMITTEE ON EDUCATION: BACKGROUND INFORMATION

When President Lyndon B. Johnson, on October 16, 1964, established the Federal Interagency Committee on Education, the programs and funds with which the Federal Government supported education had reached an all-time high. Congress since has authorized more money and larger, more diversified programs. The creation of FICE mandated the more than 30 agencies which administer educational programs to work together to achieve common goals.

SUBCOMMITTEES AND TASK FORCES

Much of the work of FICE has been accomplished by its subcommittees. In June 1966, FICE officially created its first permanent subcommittee, the Student Support Study Group (SSSG), which strives for greater consistency and efficiency in administration of all Federal student support programs, emphasizing those at the graduate level.

In November 1966, the Chairman established two more permanent subcommittees to deal with areas of education requiring intensive, on-going discussion and study:

1. The Subcommittee on Government-University Relations has, among other activities, discussed various proposals for institutional grant programs and developed recommendations, endorsed by FICE, on uniform indirect cost rates for all federally-supported education projects.
2. The Subcommittee on Manpower has engaged in continual discussion of manpower resources which are and will be required to meet the needs of American society.

In February 1968 FICE established the Subcommittee on Universe of Post-Secondary Educational Institutions. Its task is to develop a coded directory of information which can be used by all Federal agencies supporting institutions beyond high school. The Office of Education will bear responsibility for keeping it up-to-date.

The Subcommittee on Educational Statistics, organized in January 1969, has held two official meetings. Members are working to eliminate duplication in educational data collection activities and to develop a common frame of reference for all Federal statistics programs as they relate to education.

FICE ACCOMPLISHMENTS

Statement on teaching by Federal fellowship and traineeship holders, March 1967. Emanating from the Student Support Study Group, this statement expressed FICE's position that such teaching is a desirable graduate training experience which should be encouraged.

A change in the Veterans Administration policy on benefits paid to student attending unaccredited junior colleges. In October 1967 the VA agreed, at the urging of the Student Support Study Group, to accept the status "candidate for accreditation" as tantamount to accreditation, thereby permitting payment of benefits on a credit hour rather than a clock hour basis to veterans in college level courses at such institutions.

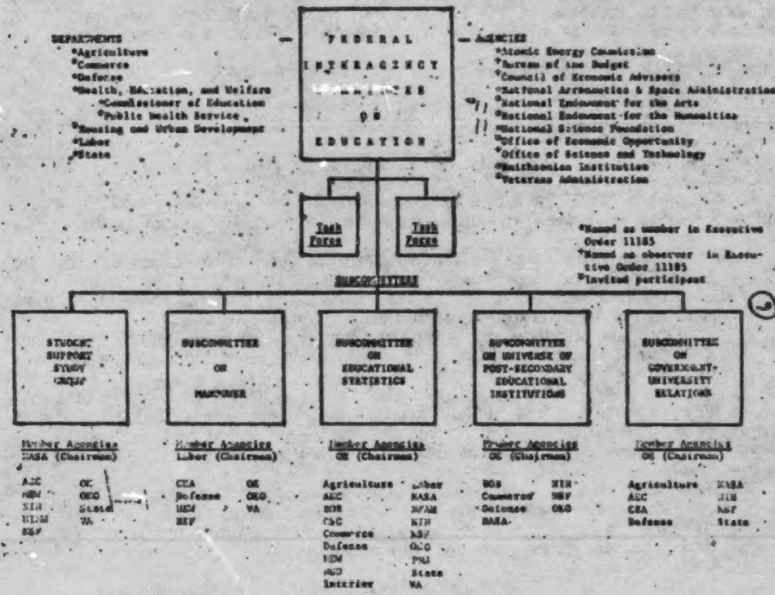
A statement dated March 27, 1968, announcing agreement by eight FICE-member agencies to a policy of holding nationally competitive Federal fellowships for graduate students who enter military service. The same agencies later agreed to extend similar coverage to conscientious objectors who fulfill their military obligation.

Agreement by FICE-member agencies to the recommendation from the Subcommittee on Government-University Relations that all agencies adopt uniform procedures on indirect costs paid to institutions of higher education for federally-supported education projects.

Report of the Task Force on Selective Service, November 1967, which called for more equitable treatment of all draft eligible men, regardless of age. As a result of the work of this task force, FICE has become a central source of information and action on issues related to the draft.

Report of the Task Force on Fellowships and Traineeships which shows a declining level of Federal support for graduate students in the fall of 1968. The report recommends intensive study of all sources of support and future manpower needs, with a view to providing an integration of the two. FICE is in the process of updating the study and will soon publish a supplementary report.

A Study of Predoctoral Student Support, which recommends increasing stipends and allowances in all Federal fellowship and traineeship programs. Released in November 1968, the report calls for Government-wide uniformity in terms and standards of such awards.


DEPARTMENTS
*Agriculture
*Commerce
*Defense
*Health, Education, and Welfare
*Commissioner of Education
*Public Health Service
*Housing and Urban Development
*Labor
*State
FEDERAL INTERAGENCY COMMITTEE ON EDUCATION
AGENCIES
*Atomic Energy Commission
+Bureau of the Budget
+Council of Economic Advisers
*National Aeronautics & Space Administration
*National Endowment for the Arts
*National Endowment for the Humanities
*National Science Foundation
*Office of Economic Opportunity
+Office of Science and Technology
*Smithsonian Institution
*Veterans Administration
Task Force
Task Force
*Named as member in Executive Order 11185
+Named as observer in Executive Order 11185
*Invited participant
SUBCOMMITTEES
STUDENT SUPPORT STUDY GROUP
SUBCOMMITTEE ON MANPOWER
SUBCOMMITTEE ON EDUCATIONAL STATISTICS
SUBCOMMITTEE ON UNIVERSE OF POST-SECONDARY EDUCATIONAL INSTITUTIONS
SUBCOMMITTEE ON GOVERNMENT-UNIVERSITY RELATIONS
Member Agencies
NASA (Chairman)
AEC
HEW
NIH
NIMH
NSF
OE
OEO
State
VA
Member Agencies
Labor (Chairman)
CEA
Defense
HEW
NSF
OE
OEO
VA
Member Agencies
OE (Chairman)
Agriculture
AEC
BOB
CSC
Commerce
Defense
HEW
HUD
Interior
Labor
NASA
NFAH
NIH
NSF
OEO
PHS
State
VA
Member Agencies
OE (Chairman)
BOB
Commerce
Defense
NASA
NIH
NSF
OEO
Member Agencies
OE (Chairman)
Agriculture
AEC
CEA
Defense
NASA
NIH
NSF
State

Federal Interagency Committee on Education: Membership List

Chairman, Assistant Secretary for Education, Department of Health, Education, and Welfare, Washington, D.C.

Douglas Batson; Deputy Assistant Secretary of State for Educational and Cultural Affairs; Department of State; Washington, D.C.

William Branson; Council of Economic Advisers; Executive Office Building; Washington D.C.

Nathan Brodsky; Acting Deputy Assistant Secretary of Defense (Education), Department of Defense; Washington, D.C.

Leonard D. Fenninger; Director, Bureau of Health Professions Education and Manpower Training; National Institutes of Health; Bethesda, Maryland.

Thomas D. Fontaine; Associate Director for Education; National Science Foundation; Washington, D.C.

Barnaby Keeney; Chairman, National Endowment for the Humanities; Washington, D.C.

William H. Kolberg: Associate Manpower Administrator for Policy, Evaluation, and Research; Department of Labor; Washington, D.C.

Robert A. Levine; Assistant Director of Research, Plans, Programs, and Evaluation; Office of Economic Opportunity; Washington, D.C.
Robert Q. Marston; Director, National Institutes of Health; Public Health Service; Bethesda, Maryland.
John M. Mays; Office of Science and Technology; Executive Office Building; Washington, D.C.
Lawrence C. McQuade; Assistant Secretary for Domestic and International Business; Department of Commerce; Washington, D.C.
Peter Miurhead; Acting Commissioner of Education; Office of Education; Washington, D.C.
Richard Nathan; Assistant Director; Bureau of the Budget; Washington, D.C.
N. P. Ralston; Deputy Director; Science and Education Division; Department of Agriculture; Washington, D.C.
Philip Ritterbush; Director, Office of Academic Programs, Smithsonian Institution; Washington, D.C.
Dr. Eli A. Rubenstein; Assistant Director for Extramural Programs; National Institute of Mental Health; Chevy Chase, Maryland.
Francis B. Smith; Assistant Administrator for University Affairs, National Aeronautics and Space Administration; Washington, D.C.
David C. Stewart; Director of Programs in Education and Public Media, National Endowment for the Arts; Washington, D.C.
James T. Taaffe; Director, Compensation, Pension, and Education Service; Veterans Administration; Washington, D.C.
Gerald F. Tape; Commissioner; Atomic Energy Commission; Washington, D.C.
Melvin Wachs; Urban Management Assistant, Department of Housing and Urban Development; Washington, D.C.
FICE Liaison:
    Emery F. Bacon; Executive Director, Federal Interagency Committee on Education; Department of Health, Education, and Welfare; Washington, D.C.
Observer:
    William G. Rosen; Executive Secretary; Committee on Academic Science and Engineering; National Science Foundation, Washington, D.C.

APPENDIX E

POLICIES FOR THE DISTRIBUTION OF PUBLICATIONS AND OTHER MATERIALS DEVELOPED UNDER THE SCIENCE EDUCATION PROGRAMS OF THE NATIONAL SCIENCE FOUNDATION

February 6, 1969

APPENDIX I

POLICIES FOR THE DISTRIBUTION OF PUBLICATIONS AND OTHER MATERIALS DEVELOPED UNDER THE SCIENCE EDUCATION PROGRAMS OF THE NATIONAL SCIENCE FOUNDATION, FEBRUARY 6, 1969

INTRODUCTION

As a result of NSF grants in support of science education projects, a very diverse group of materials has been and is being produced. Materials may be generated by NSF-supported projects in several different contexts, and these have important policy and administrative connotations. In the first context, NSF makes grants with the specific objective of supporting the development of instructional materials. As a result of such grants, textbooks, laboratory guides and other supplementary materials, instructional equipment and films and other visual aids explicitly designed for use in instruction are produced. Often these materials have wide applicability and considerable commercial sales potential. In another context, NSF makes grants for educational or training projects from which publishable materials may arise as by-products. These materials usually have little, commercial potential but are nonetheless worthy of distribution.

NSF practices covering the development and distribution of this variety of materials have evolved over the years. Experience has shown the virtual impossibility of anticipating all conceivable combinations of circumstances and establishing appropriate policy *a priori;* and, consequently the desirability of a policy which affords adequate latitude for NSF to respond effectively in unusual circumstances.

A. Basic Principles

Among the considerations on which policy is based are the following:

1. Policy must be designed to achieve maximum educational benefits for all potential users. Educational benefits will take precedence over all other considerations, including possible generation of income.

2. Both public and private interests must be safeguarded. Examples of public interests are: (a) Continuing availability of materials to those sections of the educational and scientific communities that find them useful; (b) Assurance of the integrity of the materials for a reasonable period of time in the form intended by the original creators; (c) Protection of the investment of public funds by adequate management of distribution[1] arrangements. In the private sector, the concern is avoidance, insofar as practical, of interference with normal commercial practices in the utilization of materials developed through NSF support. For instance, there should be open competition among qualified and interested organizations for distribution rights to project materials. Agreements with distributors should provide for price levels consistent with the existing competitive price structure. In the case of commercial organizations, royalties and other conditions should be adjusted to allow a reasonable but not undue profit.

3. NSF will at some point divest itself of both financial and managerial interest in the products of science education projects and place the responsibility for further development in other hands.

4. Present policy has evolved in the light of past experience. It is designed to allow flexibility and to accommodate modification as additional insights are gained on how it serves the basic objectives of NSF in the support of science education activities. The policies stated herein will be reviewed periodically and modified as needed.

B. General Policy Provisions

General policy provisions outlined in this section and amplified in the following sections apply to the full range of instructional materials for the improvement of science education developed under grants made specifically for the purpose of such development. They apply also to the incidental materials dealt with under section E. unless the grantee receives specific exemption.

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[1] Distribution as used in this paper shall include publication of written materials, film sale and rental, equipment and apparatus manufacture and sales, and related procedures for distributing project materials.

1. Distribution arrangement, either commercial or non-commercial for materials developed by projects are proposed by the grantee and are subject to approval by NSF.

2. Policy provisions apply equally to commercial and non-commercial arrangements.

3. Ordinarily, copyrightable materials shall be copyrighted by the grantee and so protected throughout their development and in their final form. Their ownership is vested in the grantee for the duration of the copyright. The grantee, as owner of the materials, may negotiate and enter into contracts with distributors. The steps leading to negotiation as well as the negotiations are monitored by NSF, and resulting contracts are subject to NSF approval. The output of projects may also include such components as instructional equipment or kits of simple materials which cannot be protected by copyrights or by patents. For such materials, a grantee may enter into NSF-approved agreements with one or more manufacturers or distributors which provide quality control by the grantee and permit the contractors to advertise the material as "approved by the grantee."

4. Both exclusive and non-exclusive arrangements are acceptable for distribution of materials. Exclusive arrangements are used when they are deemed necessary to achieve effective distribution or servicing.

5. Exclusivity may be conferred only after qualified potential distributors have had adequate notice of the availability of materials and have had an opportunity to complete for distribution rights.

6. All rights conferred with respect to materials developed with the financial support, in whole or in part, of NSF shall provide the U.S. Government a free license to use the materials for its own purposes.

7. "Domestic" distribution arrangements include the U.S. and its possessions and Canada; they are considered separately from foreign distribution arrangements.

8. Agreements for distribution of written or narrated materials normally shall convey domestic rights in the English language only. Normally all other rights, including but not limited to foreign distribution and translation or adaptation, will be managed by the publisher or distributor as agent for the grantee under agreements approved by NSF. A grantee itself, however, may negotiate agreements, subject to approval by NSF in each case for disposition of such rights. When the publisher or distributor acts as the grantee's agent in negotiating the disposition of rights, he may be allowed an appropriate percentage of the income generated by such subsidiary rights.

9. Any decision to make no external distribution of project materials is subject to NSF approval. Project materials which do not appear to warrant wide-scale distribution but do appear worthy of a limited distribution are to be disseminated in ways approved by NSF. Where such materials have income potential, the grantee may not license their use within two years after dissemination without prior approval of NSF.

10. The financial interest of NSF as an agency of the Federal Government in all materials shall be in proportion to financial support by NSF of the materials or projects; this interest shall not be limited to returns from the final materials or results only.

11. With certain exceptions as noted under section F. on *Control and Disposition of Income*, all income derived by the grantee from materials developed with NSF support must be kept in a separate account and returned to NSF at specified intervals for deposit in the United States Treasury. Reports of income are required at intervals determined by NSF.

C. Distribution of Written Materials

Distribution of written materials (hereafter referred to as publication) may be accomplished through exclusive publication agreements of limited duration. Exclusive publication may appear in some cases to be the best mechanism for assuring project-created materials sufficient exposure in the form approved by their originators in order that the materials may serve their intended purpose as models. At the same time, an appropriately limited period of exclusivity allows free use of the models by others after the materials have had a chance to become established. A key point of NSF policy is termination of NSF involvement in distribution arrangements at the end of the limited period of exclusivity.

Some of the provisions which arise from considerations of general policy and publication mechanisms are:

1. Publications produced and distributed under exclusive contracts for domestic and/or foreign distribution shall provide for royalty-free licensing of the works to others after a specified period following publication. The royalty payments

will normally continue to be required from the publisher on sales of editions developed with NSF support. However, provision will be made for an adjustment in the royalty rate upon application by the publisher provided he can demonstrate that he has not recovered his costs at the expiration of the period of exclusivity. Moreover, where the publisher brings out a revised edition without additional support from NSF after the period of exclusivity has expired, he is of course free to use parts of the original works without payment of royalty therefor.

(a) Notice of domestic free licensing shall be given by printing, adjacent to the copyright notice in the published work, the following statement or its equivalent: Except for the rights to material reserved by others, the publisher and the copyright owner hereby grant permission to domestic persons of the United States and Canada for use of this work without charge in the English language in the United States and Canada after ________ (date). For conditions of use and permission to use materials contained herein for foreign publication or publications in other than the English language, apply to the publisher [copyright owner].

(b) The period of exclusivity shall be based on the nature of the materials. For textbooks and materials of the kind that are regularly revised, the exclusivity period normally shall coincide with the expected revision period, ordinarily in the range of 4 to 6 years. In the usual instance, the publication agreement shall provide that exclusivity may not be terminated or withdrawn with less than two years' public notice given either by a statement on the title page or in appropriate trade journals.

(c) Any revision during the period of exclusivity shall be at the publisher's expense and subject to approval by the grantee and payment of royalties on the same basis as those payable on the original work. Such revision shall be printed with the same free-use statement as the original edition including the same date for termination of the exclusivity period. No such revision may be published less than one year prior to termination of the exclusivity period.

2. Foreign rights normally refer to publication, including adaptation and translation, in any language other than English outside the United States, and in the English language outside the United States and Canada.

(a) An exclusive foreign right also shall be for a limited period of years. Foreign publications shall carry with a correct notice of copyright the essence of the following statement: The copyright owner will give permission for use of this work without charge after ________________________ (date). For conditions of use, permission to use, and for other permissions, apply to the publisher [copyright owner].

(b) The exclusivity period shall be determined by the particular conditions under which the work is to be used and may, where justified, be longer than the exclusivity period for the original publication.

(c) An exclusive foreign right may be granted for a specified language, a geographic region, or a political unit, as conditions warrant.

3. In some cases, it may be desirable to arrange for publication by means of non-exclusive agreements. The general required procedures for this type of agreement are set forth in section D. on *Distribution of Films*.

D. Distribution of Films[2]

While exclusive arrangements with a single distributor are acceptable when necessary to achieve effective distribution, non-exclusive arrangements with several distributors are frequently preferable. The arrangement to be used will depend on the nature of the film, its relation to other curriculum materials, and quality control and other marketing considerations. Making films available to potential consumers also entails the selection of one or more qualified laboratories to produce sufficient prints from preprint material furnished by the grantee to satisfy the needs of the authorized distributor(s).

1. The grantee may elect to designate one or more laboratories to process preprint materials and make prints for distributors, or the grantee may permit a distributor to designate a laboratory of the distributor's choice. If the grantee makes the selection, he must provide adequate opportunity for interested and qualified concerns to be considered as the laboratory of choice. The selection procedure must be approved by the Foundation.

2. Distribution arrangements shall generally be limited to the rights to make and distribute films for use by optical projection before a viewing audience.

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[2] "Films" as used in this section shall all include such visual aids as filmstrips, short film loops, and cartridge films.

3. Exclusive distribution arrangements shall provide for optional termination by either party at the end of a mutually agreeable period which will normally be 7 years. Upon termination of an exclusive agreement, distribution may be continued subject to NSF approval, on a non-exclusive basis with royalties adjusted accordingly.

4. Non-exclusive distribution arrangements for films and visual aids shall conform to the following conditions:

(a) The availability of materials for distribution shall be made known through appropriate channels and an appropriate deadline stated for the submission of distribution proposals.

(b) No licensee shall be granted conditions which accord him an advantage or shall be required to meet conditions which place him at a disadvantage as compared with other licensees.

(c) The number of licensees shall be greater than one, provided there is more than one qualified applicant. The number of licensees may be limited by the capability of the applicants to provide all the required services and by the estimated extent of the market. Additional licensees shall not be added after the initial selection.

5. Film distribution agreements shall permit the non-exclusive sale by the grantee of a limited amount of footage incorporated in a particular film. Such sale is subject to NSF approval and shall be at customary rates and for a specified non-competitive use.

6. Film footage produced by the project but not incorporated in films for general distribution shall, after a reasonable period of time, be made available by the grantee to others at customary rates on a non-exclusive basis for a specified use.

E. Distribution of Incidental Materials

The Foundation supports science education projects whose purpose is other than the development of educational materials. In some such projects materials of potential educational use are developed as an incidental by-product. When NSF grant funds were used directly for the development of those materials and when the plans for the distribution of these materials include publication for sale, NSF will exert a control over the distribution rights and income in a manner consistent with the control over non-incidental educational materials.

F. Control and Disposition of Income

NSF may permit the grantee to retain some amount of royalty and/or other income in the following cases:

1. If the grantee is exempted in accordance with the section on *Distribution of Incidental Materials*, NSF may elect to (a) waive return of income, or (b) require return of income for a limited period, e.g., three years or until NSF investment has been recovered. Thereafter, the grantee may retain any further income for additional science education activities. In all cases, periodic reports of income for the first three years following publication or distribution are required. Provisions 2, 3, and 4 in this section may also be applicable to income, derived by the grantee from incidental materials.

2. If, when the substantive work of a project has been concluded, there still remain administrative expenses arising from the grant, the grantee may request an amendment to the grant from NSF to retain some amount of royalty and/or other income to be used to defray these expenses.

(a) When the anticipated administrative costs including overhead are less than $2,500 per year, no budget need accompany the request to use income funds.

(b) When the anticipated administrative costs including overhead exceed $2,500 per year, a budget proposal detailing expenditures must be submitted for NSF approval.

Periodic reports on use of income for administrative purposes are required.

3. If the gross annual royalty and/or other income to the grantee is only nominal, the amount to be established by NSF, and the grantee is a non-profit organization, the income may be retained by the grantee provided that it is first used to defray administrative expenses arising from the grant. Periodic reports to NSF of expendtiures under this provision are required. When the royalty and/or other income for two consecutive years does not exceed an amount to be determined by NSF, the grantee may request NSF to release him from further obligation to account for or return income to the Federal Government. In addition, when the income from sales or rental of films has declined for two successive years to an amount to be determined by NSF, the grantee may request NSF to relinquish a control over disposition of title to the materials, disposition of rights to use, and income derived therefrom.

4. If the gross annual royalty and/or other income to the grantee is less than $1,000, it may be retained by the grantee provided it is used first to defray administrative expenses arising from the grant and second to further science education activities of the grantee.

These funds shall not be distributed to private individuals except for additional services from them. Periodic reports to NSF of expenditures uner this provision are required. When the gross annual royalty and/or other income does not exceed $1,000 for any three successive years, NSF will require no further accounting.

5. Temporary income utilization by the grantee is permitted, when authorized by NSF, in the cycling of a revolving fund establishd for an appropriate specific purpose such as, but not limited to, sale at cost of preliminary versionsof materials. Periodic status reports on revolving funds are required.

APPENDIX F

PRE-COLLEGE SCIENCE CURRICULUM ACTIVITIES OF THE NATIONAL SCIENCE FOUNDATION: REPORT OF SCIENCE CURRICULUM REVIEW TEAM: MAY 1975

Vol. 1—Findings and Recommendations

Pre-College Science Curriculum Activities of the National Science Foundation

REPORT OF
SCIENCE CURRICULUM REVIEW TEAM

MAY 1975

Volume I—Findings and Recommendations

[illegible]

FOREWORD

A special review team was appointed by the Director of the National Science Foundation, H. Guyford Stever, for the purpose of reviewing the NSF program in pre-college science education.

The review team, as directed, completed a detailed study of pre-college science curriculum development and implementation activities. The development of policies and operational procedures were traced over the past quarter of a century and their impacts on management practice were analyzed. A carefully delimited study of all curriculum development projects was carried out and five representative projects were examined in depth. Background studies by outside consultants were commissioned and a substantial body of data was collected for use in preparation of the report.

The report of the review team is presented in two parts—Vol. I.—*Findings and Recommendations* and Vol II.—*Appendix*. Vol. I summarizes the extensive work of the review team. It presents the general findings of the study, along with the principal observations of the team, and highlights the major policy issues that formed the basis of discussion for a special meeting of the Advisory Committee for Science Education. Recommendations of this Committee as submitted to the Director, NSF, are included. Finally, recommendations made by the chairman of the review team are presented for consideration by the Director and the National Science Board.

As might be expected in any detailed review of a complex judgmental process, the review team identified many areas of administrative practice that could be improved. These include, but are not confined to, the need for better definition of internal documentation, more explicit criteria for selecting reviewers, and clarification of procedure followed in the modification of proposals in response to reviewer comments. While all are of importance to proper program performance, they can and should be addressed satisfactorily through normal administrative action, and, therefore, have not been taken up in detail in the report.

Vol. II—*Appendix* will include many of the basic documents used to arrive at the findings and recommendations of Vol. I. They include an historical overview of the factors impacting on NSF policies and programs in pre-college curriculum development and implemention, detailed summary case studies of five major projects, publication policy and financial arrangements, a summary audit and curriculum development financial arrangements. Attention is invited to the two contracted background papers which address important issues of curriculum implementation and commercial curriculum development activity.

In my opinion, the report is straightforward, factual and speaks directly to important issues. It is remarkably comprehensive considering the relatively short time available to the research team and supporting staff. Under the direction of Dr. Joel Snow, the team remained objective throughout and provided a balanced analysis that honestly addresses both strengths and weaknesses of the program.

I want to express my appreciation to the review team members and to the other members of the staff who contributed much time, thought, and effort to the development of this report, often with considerable personal sacrifice.

Robert E. Hughes
Assistant Director/National and International Programs
Chairman, Science Curriculum Review Team

EXECUTIVE SUMMARY

On April 7, 1975 the Director, National Science Foundation appointed a review team to undertake a detailed study of the pre-college science curriculum activities of the NSF. The team has completed its study and has submitted its report in two volumes; Volume I, *Findings and Recommendations*, and Volume II, *Appendix*.

After extensive investigation and development and analysis of a substantial body of data, the review team has made the following observations:

- The program has been instrumental in bringing about a major change in the content of science teaching materials at the pre-college level
- No comprehensive review of future needs for pre-college curricula has been carried out, although there has been extensive change in the national situation with respect to these curricula
- There is a need for substantial reexamination of the policy framework of this program
- Project management decisions conformed adequately with policies, procedures, and practices in effect at the time decisions were made
- General NSF management practices were consistent with policies in effect at the time
- While there has been steady improvement in operational and management practices, additional improvements can be made.

Five general policy issues were identified. These are:

- Redefinition of the NSF role in curriculum development
- Determination of future needs
- Open competitive process for selection of awardees
- Strengthened proposal review and project evaluation processes
- Redefinition of the NSF role in curriculum implementation.

These observations and issues were discussed in detail on May 9-10, 1975, among members of the team and the Advisory Committee on Science Education. The Committee then made the following recommendations:

- NSF has a continuing role in science curriculum development at the pre-college level; NSF should not avoid controversy at the expense of educational and scientific value;
- NSF should take an active and continuing role in determining needs for improvement of pre-college science education
- NSF should use a broad range of granting mechanisms, including expanded use of "program solicitation" procedures
- All large scale projects should have detailed evaluation plans and make provision for external summative evaluation
- Developers should be encouraged to make arrangements for publication, manufacturing, and marketing without a requirement for NSF funds.

The chairman of the review team, after consideration of the results of the study and discussion with members of the NSB, made the following procedural and policy recommendations.

PROCEDURAL

- A needs assessment program should be initiated to develop and establish priorities for curriculum development
- Procedures should be developed to guarantee broad dissemination of needs, competitive proposal procedures, review by qualified professionals and, when appropriate, pilot testing of competing courses
- Formal in-depth review of completed curriculum development programs should be carried out
- More formal, structured procedures should be established for periodic review of ongoing major curriculum development programs
- Barriers to broad diffusion of new curriculum materials should be researched and results broadly disseminated to allow and encourage State and local authorities to exercise their total responsibility for adoption of curriculum materials
- The NSF should ensure, by legally binding agreements, that all curriculum development grants include the NSF disclaimer clause.

POLICY

- The National Science Board should develop a definitive policy statement on the purposes and objectives of NSF curriculum development activities. This statement should delineate the extent to which future activities in both the natural and social sciences should be directed toward the objectives of supporting science training specifically for individuals embarking on science careers, and science education for *all* students to illuminate the underlying nature of our technological world.
- The National Science Board should formulate a clear policy statement on the role of the NSF in natural and social science curricula implementation. Since curriculum implementation activities are designed to disseminate materials that are sometimes regarded as controversial or political in nature, a clear policy is needed for the guidance of future activities.
- Mechanisms for administering curriculum implementation that allow NSF to remain at "arm's length" from the process are needed. New approaches should involve State and local authorities, private institutions and academies.

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I. Purpose and Design of the Study

Dr. H. Guyford Stever, Director of the National Science Foundation established a special Science Curriculum Review Team to undertake a detailed study of all pre-college science curriculum activities of the NSF. The review team was charged with developing an analysis of the policies, procedures, and practices of the program from its inception to the present. Further, the team was to determine whether NSF procedure was adequate to ensure that:

- proposed subject matter fits within reasonable limits or norms with respect to educational value;
- scientific content is accurate;
- course developers are responsible and competent persons;
- institutional and contractual arrangements are sound.

Additionally, Dr. Stever stressed that:

- the study and analysis should be in all respects independent and objective,
- the examination of cases and experience should be complete and unbiased by our previous practices,
- scrutiny of the fiscal and management approach should be thorough and unhindered by past commitments;
- potential or real conflicts of interest must be carefully addressed,
- NSF policies and practices are to be carefully scrutinized to ensure that the appropriate role of NSF in curriculum development is being followed.

Dr. Stever further directed that the study team ensure that:

- a thorough examination of past practices is undertaken,
- a rigorous analysis of business and contractual relationships is developed, and
- positive recommendations for improving the program's practices are developed.

"A fully effective analysis of these issues is essential to honest examination of the integrity of our curriculum programs.

> "As you know, I am committed to reporting our conclusions to the Congress after appropriate discussion with the Advisory Committee for Science Education and the National Science Board. Your work is a crucial element in formulating this report. Let me urge you to require that in every respect that this study will be a model of objective and professional analysis."

In his letter of April 1, 1975, to Congressman Olin E. Teague, Chairman of the House Committee on Science and Technology, Dr. Stever outlined the structure of the analysis to be undertaken.

> "In my NSF review I plan to have investigated the pre-college curriculum development activities in a broad sense, including MACOS particularly and also the program more generally. To do this, some procedural questions will be studied; for example, the distribution rights and royalty arrangements. In addition to a general survey of all of the curricula that have been developed, I shall have the review team make a detailed study of several cases as well as MACOS to see what they illustrate about the procedures that NSF has used in the support of curriculum development. The review will examine the following:
>
> (A) Curriculum Development Program
>
>   (1) History
>
>   (2) Case Studies
>
>   a. CHEM Study (Chemistry curriculum), 1959-1972
>   b. Science Curriculum Improvement Study, (SCIS) 1962-Present
>   c. Man: A Course of Study (MACOS) 1963-1970
>   d. Comparing Political Experiences (CPE) 1972-Present
>   e. Individualized Science Instructional System (ISIS) 1972-Present
>
> (B) NSF Distribution Policy and Royalty Arrangements
>
>   (1) History
>   (2) National Science Board Policy (1969)
>
> (C) Curriculum Implementation Procedures
>
>   (1) History
>   (2) Research Studies Regarding Implementation
>   (3) Current Practices
>
> (D) Evaluation Procedures for Establishing Content and Utilization

(E) Practices and Procedures in Science Curriculum Developed by Other Organizations

(F) Recommendations

Designated members of the team included:

Dr. Robert E. Hughes, Assistant Director for National and International Programs (Chairman of the Review Team)
Dr. Grover E. Murray, Member, National Science Board, and President, Texas Tech University and Texas Tech University School of Medicine
Dr. L. Donald Shields, Member, National Science Board, and President, California State University at Fullerton
Mr. Robert B. Boyden, Audit Officer
Dr. Eloise E. Clark, Director, Division of Biological and Medical Sciences
Dr. James D. Cowhig, Deputy Director for Public Sector Productivity
Mr. Walton M. Hudson, Budget Officer
Dr. J. Arthur Jones, Program Analyst, Office of Planning and Resources Management
Mrs. Maryann B. Lloyd, Deputy General Counsel
Mr. Leonard A. Redecke, Contracts Administrator
Dr. Joel A. Snow, Director, Office of Planning and Resources Management (Executive Secretary of the Review Team)

Many other members of the NSF staff with scientific, grant and contract, financial management, and research management experience were called upon to contribute to the study. Members of the Education Directorate staff provided source material and assisted in the development of factual data. It is important to note that none of the members of the review team had worked in the programs being investigated.

A major effort was undertaken to analyze practice and procedure in five curriculum development projects. The five examples were chosen to represent a wide range of fields of science and are at differing stages of program development; one is totally completed and "closed out," two have completed the development phase and are being implemented; and two are still under development. It is believed these examples provide a representative view of the evolution of NSF procedures for curriculum development and implementation.

Project case studies were carried out by review team task groups which also included experienced NSF officials with professional backgrounds in both science and business practice. Each task group was instructed to examine the grant records over the lifetime of the project and to document how each significant project decision was made.

In the examination of project files the review and monitoring history of each project and the decision making process were analyzed.

The results of this detailed analysis were transmitted in writing and with full documentation as internal working papers, to the Executive Secretary of the review team. After completion and critique of this analysis, each task group prepared a summary report describing the curriculum project and developed recommendations for possible improvement of program practice or policies. Appendix 4 comprises the summary case study reports.

A general survey covering a sampling of all 53 NSF curriculum development projects was also undertaken to determine whether the issues raised in the course of the case studies were isolated instances or were more widespread. In addition to the above analyses, working documents were developed which related to each of the items identified in the outline (page 2). Particular attention was paid to the business and financial elements of the projects. The distribution policy and fiscal history were reviewed and audit reports were prepared on each of the case study projects. A summary of these audit reports is found in Appendix 5; the individual audit reports are on file.

The roles of NSB, the Congress and the Executive Office of the President in developing NSF policy in the pre-college curriculum area were examined. In addition, background studies were commissioned on the practices of the publishing industry and its relationship to government funded projects and on the extensive research literature relating to curriculum implementation. The Office of Education and the National Institutes of Education provided information about their practices, and finally, an analysis of evaluation and oversight procedures was prepared. These working documents and the case studies provide the basis for the analysis presented in this report; many of the documents can be found as appendices to this report, Volume II.

The final report was prepared by a group assembled by, and under the direction of the Executive Secretary of the review team.

II. Findings, Observations, and Policy Issues

This section contains a general survey of curriculum projects and synopses of five case studies chosen for detailed analysis by the review team. Also presented are observations that represent a consensus of the review team. Policy issues that were identified during the study are organized to reflect the flow of activities in curriculum development projects and were discussed jointly by the members of the review team and the Science Education Advisory Committee in meetings held May 9 and 10, 1975.

Director Stever charged the review team and Committee with ensuring that:

- the proposed subject matter fits within reasonable limits or norms with respect to educational value
- the scientific concept is accurate
- the course developers are responsible and competent persons
- the institutional and contractual arrangements are sound.

The list of 53 curriculum projects follows. More than half were reviewed in some depth by the team. Detailed case study summaries from which the synopses were drawn are to be found in Volume II, Appendix 4.

LIST OF CURRICULUM PROJECTS

	Curriculum Project	*Current Status*
**1.	Physical Science Study Committee (PSSC)	Completed
**2.	School Mathematics Study Group (SMSG)	Completed
3.	Chemical Bond Approach (CBA)	Completed
**4.	BSCS Biology	Completed
*5.	CHEM Study	Completed
6.	Elementary School Science Project—University of California	Completed
7.	Elementary School Science Project—University of Illinois (Atkin)	Completed
8.	TV Program for Mathematics Teachers	Completed
9.	Syracuse Webster Mathematics Projects (Madison)	Completed
**10.	Elementary Science Study (ESS)	Completed
**11.	Anthropology Curriculum Study Project (ACSP)	Completed
**12.	Science-A Process Approach	Completed
13.	University of Illinois Committee on School Mathematics	Active
14.	MINNEMAST	Terminated

*15.	Science Curriculum Improvement Study (SCIS)	Completed
**16.	Earth Science Curriculum Project (ESCP)	Completed
17.	School Science Curriculum Project—University of Illinois (Sallinger)	Terminated
*18.	Man: A Course of Study (MACOS)	Completed
19.	Elementary School Science Improvement Project—University of Utah (Wood)	Terminated
20.	Secondary School Science Project (Time, Space, Matter)	Completed
**21.	Introductory Physical Science (IPS and PS II)	Completed
22.	Films for In-Service Education of Teachers of Elementary School Mathematics	Completed
23.	Quantitative Approach in Elementary School Science	Completed
24.	High School Course in Modern Coordinate Geometry	Completed
25.	High School Geography Project (HSGP)	Completed
26.	Sociological Resources for the Secondary Schools (SRSS)	Completed
27.	Engineering Concepts Curriculum Project-Man Made World	Completed
28.	Elementary Mathematics Projects (Arithmetic Project)	Completed
29.	Harvard Project Physics (PP)	Completed
30.	Portland Interdisciplinary Science Project	Completed
**31.	Intermediate Science Curriculum Study (ISCS)	Completed
32.	Improvement Project in Mathematics for Subcultural Groups (Gibb)	Completed
33.	Secondary School Mathematics Curriculum Improvement Study (SSMCIS)	Completed
34.	Computer Based Self-Instructional Course for Supplementary Training of Secondary School Teachers of Physics	Completed
35.	Environmental Studies for Urban Youth (ES)	Completed
*36.	Comparing Political Experiences (CPE)	Active
37.	Biomedical Interdisciplinary Curriculum Project (BICP)	Active
38.	Demonstration and Experimentation in Computer Training and Use in Secondary Schools (Dartmouth)	Completed
39.	Boston University Mathematics Program	Active
40.	Development of Computer Simulation Material (Huntington II)	Completed
41.	Development of Teacher Training Materials in Math (HCTH)	Completed
42.	Experimental Teaching of Mathematics in Elementary School (Suppes)	Terminated
43.	Exploring Human Nature (EDC)	Active
44.	First Year Algebra with Application Project	Active
45.	Human Behavior Curriculum Project (APA)	Active
46.	Human Science Program (HSP)	Active
*47.	Individualized Science Instructional System (ISIS)	Active
48.	Mathematics Problem Solving Project	Active
49.	Mathematical Resources Project (Hoffer)	Active
50.	Outdoor Biology Instructional Strategies (OBIS)	Active
51.	Project for the Mathematical Development of Children	Active
52.	Technology-People-Environment (TPE)	Active
53.	Unified Science and Mathematics for Elementary Schools (USMES)	Active

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* 5 Case Studies

** 9 projects selected for relatively intensive review

FINDINGS

Findings of the review team members are summarized in the General Survey of Curriculum Projects and synopses of the five case studies.

It must be strongly stressed that the material presented here is structured to identify and highlight problem areas and does not reflect the overwhelming extent to which the procedures and administrative activities represented good judgment and sound management.

GENERAL SURVEY OF CURRICULUM PROJECTS

To fulfill the Director's charge, the review team sought to identify any problems—past, present or future—of possible public concern. More than half of the 53 projects were screened for indications of procedural ineffectiveness and to determine the degree of compliance with established policies. Six procedural areas were considered in the survey: (a) needs assessment, (b) proposal generation, (c) proposal evaluation, (d) development monitoring, (e) evaluation of materials and processes, and (f) arrangements for production and distribution.

Nine sample projects, in addition to the case studies mentioned, were selected for a relatively intensive review. They were chosen because they represent a significant fraction of the total NSF obligations in the field—an aggregate obligation of $95 million—which, along with the $30 million obligated for the five case studies, covers 76 percent of the total amount obligated for curriculum development and implementation.

NEEDS ASSESSMENT

Strengthened external review procedures will be required if effective mechanisms are to be created for the determination of needs for new curricula. This is illustrated by some of the following problems identified in the course of the study.

Typically, a needs assessment related to a particular field is performed by a conference of scholars and educators in that field. Experience has shown that it is commonly assumed by conferees that a need *in fact* exists, and that the question of *how* to improve a curriculum is to be addressed. This assumption of need during development of certain projects has resulted in a less than clear definition of goals. Lack of specificity in early development stages, reliance on conclusions of study groups on other topics, and the modeling of projects on existing examples has at times created doubts concerning the need for a new course.

In some instances, projects have been spin-offs, initiated in fields not previously taught as separate disciplines; others have been initiated primarily because they complement existing projects; and yet others are open to question because of their sheer number, e.g., twenty projects in the field of mathematics. Heavy expenditures for preparation of texts in one project drew criticism because it was argued that private enterprise was meeting the need.

Procedures requiring a systematic and independent assessment of the need for projects are less than adequate. Clearer statements of needs would improve NSF's ability to generate a broader base of interest in potential development projects, provide a framework upon which competitive proposals could be evaluated, and could enhance the basis for monitoring development and evaluating results.

PROPOSAL GENERATION

Ordinarily a proposal to undertake curriculum development is submitted in response to informal encouragement by the Foundation of a source whose credentials have been established and who is perceived as responding to a potential need. In this survey no case was found where competitive proposals for the same project exist. Further, the Foundation has taken no explicit position on competitive solicitation.

Criticism could be directed at certain proposal generation practices which may have led to questionable results. Examples include the charge that formation of a corporation was a direct result of one project grant; that some proposals have been developed in direct consultation with the Foundation; that other projects have been transferred from one institution to another along with the project director; and that there have sometimes been no records to indicate how the transfer or acquisition of a particular project was effected by a grantee.

A more normal competitive solicitation procedure, if instituted, could result in more focused delineation of specific needs, more definitive short- and long-term planning and should elicit more detailed, and in some instances, more realistic cost estimates.

PROPOSAL EVALUATION

The need for outside review prior to initial funding becomes evident when it is realized that an award in seven figures for a continuation of work has occasionally been granted after review by one individual, albeit subject to approval by higher management. Initial funding, it appears, has in some instances been granted without benefit of more than cursory staff review.

Proposals to initiate major phases of a project are ordinarily subject to mail and NSF divisional committee review. Mail reviewers' complaints that some proposals were too extensive or complex to be given more than a global appraisal are supported by many of the reviews examined by the team.

Often, in current practice, evaluation is performed by a single project director which has led to his "owning" it and becoming the ultimate authority on its nature, success and value. While this procedure is of merit in a research program, it is less felicitous in these costly projects that are designed to meet specific public needs, and which would benefit from expanded outside review.

As in other procedural matters, judicious proposal evaluation would encourage development of explicitly stated goals, well formulated plans, and a realistic budget clearly related to the project plan.

MONITORING OF DEVELOPMENT

While the Foundation's monitorship of most projects appears to have been broad, vigorous and responsible, it appears to have lacked a systematic approach. The files examined reveal extensive but occasionally incomplete records on administrative, financial, and technical matters, and it appears that most contacts with NSF staff were initiated by grantees. Few progress reports were found, and those on file were normally submitted with a request for renewal of support.

Advisory groups are not required by NSF but are usually formed by grantees to monitor projects under development. If the Foundation relies on these groups, it runs the risk of becoming captive to the grantee whose creature the advisory group almost inevitably is. True neutrality in such an autonomous arrangement is difficult, and the deliberations of these groups would appear to merit more stringent monitoring.

Generally, a policy of neutrality has been maintained on substantive matters, but where the Foundation has been the sole source of support for a large grantee organization, it has usually accepted responsibility for the grantee's salary and employment practices. In a few cases, this practice may have resulted in excessive disbursements or an inappropriate degree of Foundation intervention in fiscal practices of the grantee.

There is further evidence that suggests the need for increased monitoring. Major awards have sometimes been deemed necessary to continue efforts on certain projects in order to glean useful materials from earlier disappointing performances. Lack of monitorship has resulted in continued support of some projects where the aims of the Foundation and the grantee have, over time, diverged; where tangential activities have been pursued to the detriment of the goal; and where empire building tendencies on the part of the grantee have become evident. Weaknesses could be corrected by more active monitoring and by clarification of policy on Foundation support of revision costs and by setting maximum personnel per capita costs.

A model or detailed plan is needed to provide a framework for evaluating status information. Such a model should include a basis for evaluating the acceptability of subject matter, accuracy of its content, the competency and responsibility of potential course developers, and the soundness of institutional arrangements.

EVALUATION OF MATERIALS AND PROCESS

The question here is to determine whether materials and processes under development respond to the needs, goals and specific objectives originally addressed in the project plan. This differs from the "formative" monitoring and evaluation described above. An effective example of this type of evaluation is demonstrated by *The National Longitudinal Study of Mathematical Abilities* in which students were followed for five years to determine effects of conventional, SMSG, and other new course sequences on performance in mathematics and science.

Lack of a systematic procedure for evaluating project results has left the Foundation vulnerable to such criticisms as sponsorship of materials development beyond its legitimate sphere, or support of courses which touch upon value-charged matters in a possibly insensitive or ineffective way. Materials cited have included those which apparently treat evolution as a fact rather than a theory; deal, however obliquely, with religious institutions, ethnicity, human behavior, birth control, and reproduction; and those using living materials. It is not claimed that science related to these subjects should be excluded from support, but rather that NSF lacks a systematic procedure that would ensure monitoring of the use of potentially controversial materials and that would also ensure careful decision making.

Elitism is yet another charge that has been leveled at some projects—those which lead to the benefit of but a few—while the content of others has been judged too difficult for the average student targeted. Following the adoption of some courses, the level of enrollments has actually dropped. Random reactions to implemented courses on the part of evaluators have run the gamut from "too highly structured," "of limited usefulness," "too vigorous," to the expression of belief that teachers are not always adequately prepared to handle the new course material. Another reason given for lack of widespread adoption of some courses is simply that they cost too much.

A more systematic procedure for the evaluation of projects after implementation should be viewed as a high priority need in science curriculum development.

ARRANGEMENTS FOR PRODUCTION AND DISTRIBUTION

Such arrangements are usually made by the developer, but are normally subject to Foundation approval of subcontracts and disposition of income. Some evidence of procedural inadequacy was found in this area where Foundation approval was either not sought, or informally given, perhaps because most action is between grantees and subcontractors. However, free and effective competition seems to have been a normal practice, with contracts awarded to the lowest fully qualified bidders.

Authors paid from grant funds were commonly permitted to publish their work commerically, provided their royalties were paid over to the grantee.

Records indicate that income from development projects has been closely controlled by the Foundation. Typically, it is deposited in a special account and disbursed only with Foundation approval. Nearly $12 million have been returned to the Foundation by sixteen of the projects. Revolving funds were set up to finance publication in a number of the projects surveyed.

A recurrent issue appears to have been whether income could be used to finance the revision of curriculum materials. It is clear from the records examined that NSF has not adopted an unequivocal position on this question.

Recognizing that the selection of subject matter is a responsibility of school authorities, the Foundation, has, as a rule, limited the use of grant funds to the development of new materials and the dissemination of information about them. It has left publication and distribution arrangements to private enterprise. While it relied on its grantees to manage these processes, the Foundation has maintained ultimate control over them and is therefore indirectly accountable for the widespread distribution of experimental textbooks. Produced as paperbacks, these trial textbooks may have competed during the test phase with regular published editions. This suggests another area requiring policy definition by the Foundation.

SYNOPSES OF CASE STUDIES

The five case studies used were chosen for extensive examination because they are at different stages in the total process, because they represent different disciplines and reflect ways in which methods of development may have varied over the years. Again, the aim was to identify program procedures and potential problems, thus most findings relate to administrative practices rather than general policy.

Administrative decisions are necessarily contingent upon a policy framework. The foregoing survey and the case studies, synopses of which follow, served as an aid in staff and Committee development of the Observations and Policy Issues presented in this section.

SYNOPSIS OF CHEM STUDY REVIEW

The CHEM Study project which was initiated in 1960 and continued until 1972, had as its goal "organization of a chemical educational materials study to prepare, through research and study, textual and experimental material to aid in development of a modern chemistry teaching program for U.S. high schools."

The published material developed in the CHEM Study program includes a textbook, laboratory manual, teacher's guide, a series of achievement examinations, other supplementary programs and 29 films. Additional reading lists, wall charts and lab equipment items were developed.

Dr. Glenn T. Seaborg, University of California, Berkeley, was asked to assume leadership for the proposed revisions. A steering committee of experts was established to develop a detailed plan for content; compile lists of contributors, writing groups, and trial teachers; set target dates and develop an outline for initial testing in high schools. Following endorsement from NSF and after review by the NSB, an award to initiate the project was made.

By 1965, in addition to its widespread use in the U.S., the material had been adopted in many parts of Canada, India, New Zealand and Australia, and by 1968 the material had been translated for use in 13 foreign countries.

In the U.S. the materials were widely and quickly adopted and their use persists to the present, with minimal use estimated to be 25% of all high school students. CHEM Study materials, including revisions and derivations run well over 60% usage.

Review and Oversight History

These mechanisms reflect traditional practices of the Foundation. By definition this requires acquaintance and communication with scientists carrying out the work.

The CHEM Study proposal received staff review and review by experts outside NSF prior to that of the NSB. The steering committee remained as the advisory and policy group and gave overall direction to the project. NSF closely monitored developments and participated in meetings with the Steering Committee throughout the development, revision and evaluation stages and thus was able to represent its viewpoint.

Monitoring History

NSF staff followed the development of the project closely. Fiscal reports and annual reports of progress were required in the terms of the award. At a managerial level, the NSF staff was essentially in continuous contact with the progress of the project. Informal reports were frequent, advice and confirmation of proposed directions were given prior to undertaking the activity. Questions involving selection of publishers and distributors, royalty income, etc., were forwarded to NSF legal counsel for verification of compliance with NSF and Federal policy. The pattern of advance planning with NSF feedback and subsequent action was firmly established in the CHEM Study project. The project directors, in turn, made conscientious efforts to keep NSF fully and currently apprised of progress and solicited advice on anticipated directions and problems.

NSF staff made frequent site visits to the central project office at Berkeley and to regional centers after they were established. They attended planning and writing sessions and meetings of the Steering Committee. A CHEM Study newsletter was developed and formal descriptions of the course were published in a wide variety of educational journals.

In 1966, accounts were audited by NSF, and required minor changes concerning indirect costs; no improprieties in the use of funds were found.

The evaluation of content was built into the project from the outset. The first draft of the text was written and put to use in classrooms within three months. Reactions of teachers and students were fed back to the project director after use of each section, thus, modification and revision of the text was a continuous process. Periodic meetings with participating teachers were held to exchange ideas.

By the second year, the text was virtually complete. The teacher's guide was developed almost entirely from teachers' suggestions. In subsequent years heaviest effort was devoted to supplementary material, specialized aids and teacher training, again using the mechanism of testing, evaluation, feedback and revision.

Suggestions for revision, identified problem areas, and student and teacher evaluations were assimilated and acted upon under the advisement of the Steering Committee and NSF. Deadlines were met, and copies of material were available for testing by the end of the first summer's work.

Contractual Arrangements

In December 1960 the CHEM Study staff solicited proposals from those interested in servicing, printing and distributing the materials. After review, the staff and Steering Committee recommended W. H. Freeman and Co. be awarded the contract—which was satisfactory to NSF in all respects. Subsequent film arrangements were equally satisfactory.

Based on information contained in the Foundation's files, it appears that the CHEM Study project was managed in accordance with NSF's and NSB's policies on distribution, royalties, and copyrights and that good business practices were followed.

A complete and detailed study of all financial arrangements is found in the case study, Appendix 4.

Implementation/Dissemination History

It was determined that the materials produced should be competitive with current texts, and that the packaging should be flexible in order to allow selective utilization and easy adaptation of both equipment and supplementary materials. Participants in policy discussions at NSF, with advisory committees and project personnel recognized that "product acceptance" and utilization were the ultimate goal for this effort. At the same time, NSF repeatedly reiterated its position that its funds could not be used for promotion and distribution of the materials and that selection of materials for use in schools resided with State and local authorities. Funds could, however, be used for the dissemination of information about the project, and indeed the grantee was obligated to publish reports on the project in national journals.

Early in the study, inadequate teacher preparation in the sciences was recognized to be as much a problem as poor curricula. Gradually, the summer institutes adopted CHEM Study materials, and as teachers became acquainted with them, materials were adopted for use in classrooms around the country. The newsletter and publications generated many requests for consultant assistance in adopting the materials in schools as well as privately sponsored institutes. In addition, a series of conferences were initiated for key personnel. Except for this initiative, no other formal implementation mechanisms were considered for the CHEM Study Program.

SYNOPSIS OF SCIENCE CURRICULUM IMPROVEMENT STUDY (SCIS) REVIEW

The SCIS project currently under way at the University of California at Berkeley, begun in 1962 and scheduled to continue until 1977, is focused on developing a framework of fundamental science concepts related to students' own experience with natural phenomena. To date, SCIS has developed several ungraded, sequential physical and life science programs. There are six units for a physical science sequence, and six for a life science sequence for elementary grades and one unit designed especially for kindergarten. Each has been carefully evaluated by SCIS staff during development and all were tested throughout the Nation prior to publication.

The six basic physical science units are designed to introduce and develop concepts leading to science literacy; the life science sequence focuses on organism environment interaction. Either may be used independently, but units within each are designed to be sequentially presented.

Class materials are in the form of a kit for a teacher and 32 children containing all materials save standard classroom supplies and certain fresh water organisms sent separately on request. Each complete kit costs between $125 and $280; refills cost between $8.00 and $60.00. A complete set of the K-6 SCIS kits would cost approximately $2,700.

The SCIS program is designed to foster laboratory-type experiences in which students deal directly with live animals and real objects. Objectives for each activity are well specified in the teacher's guide, but are not presented in student texts to avoid hindering the explorational and experimental aspects of learning.

To teach SCIS programs effectively, the developers recommend that the teacher have sufficient background in science and the program to profit from its inherent flexibility. The developers have therefore maintained a strong emphasis on in-service training for teachers at SCIS headquarters in Berkeley and at the other SCIS trial centers. Other conferences and courses have been made available through the publishers, developers and other colleges and universities.

SCIS units and materials are presently being used to some extent in almost all states. Sales estimates by the publisher (Rand McNally & Co.) indicate that more than 3% or approximately 1 million students in the elementary grades are now using SCIS, and it is projected that by 1977 a minimum of 15% of the school aged population will have been exposed to the program. The program has been modified for use by blind children.

Its continued use will depend on whether school personnel are willing to spend a larger share of their limited funds on elementary school science, and on effective training of teachers.

Review and Oversight History

From inception of the project through December 1970, formative evaluation was conducted by project staff. Evaluation generally moved from discussion and testing of the exploratory version to classroom trials, revision and retrial. In the spring of 1970, NSF supported an evaluation workshop, and in spring 1971 development of evaluation supplements was begun to serve teachers who needed external assistance to evaluate student performance. These were completed in 1974. Plans for a summative evaluation are being developed by NSF staff.

Monitoring History

Monitoring of the SCIS project by NSF personnel appears to have been minimal, and at best appears to have been in the form of reactions to stimuli from the SCIS project director. Major interactions between NSF and SCIS staff appear to have taken place only directly following NSF receipt of annual SCIS proposals or when SCIS personnel suggested budget changes.

Contractual Arrangements

NSF personnel approved the selection of all publishers/distributors for SCIS materials and agreed to all contractual arrangements between SCIS (U.C., Berkeley) and the publishers/distributors. Sound legal and business practices appear to have been followed.

Dissemination/Implementation

Characteristics of SCIS implementation followed the following pattern:

1. School leaders obtain funds, arrange training.
2. Pilot run of programs.
3. Key people are chosen, attend program at Berkeley involving training, observation, conferences.
4. Key personnel train local teachers.

A newsletter is published quarterly which reaches more than 25,000 readers. In the summer of 1974 NSF funded implementation projects nationwide with 1600 participants involved extensively with SCIS materials, concepts, philosophy and teaching methods.

The summary case study of the SCIS project is found in Appendix 4 and is accompanied by a list of perceived problems.

SYNOPSIS OF MAN: A COURSE OF STUDY (MACOS) PROJECT REVIEW

As described to the National Science Board on August 8, 1963, "This project is part of a comprehensive plan for developing a carefully integrated sequential social science-humanities program for elementary and secondary schools." A primary emphasis was on producing ethnographic film studies to deal with the questions: What is human about human beings? How did we get that way? How can we be made more so? The curriculum was designed to introduce organizing ideas early and restate them frequently by the use of films of people in other, and apparently quite different cultures. Students were to be encouraged to learn to use anthropological and ethnographic methods and materials.

During June 9-23, 1962, prior to any NSF support, Educational Services, Inc. (ESI) sponsored an Endicott House Conference in Dedham, Massachusetts, ". . . to develop an overall unifying approach that would provide guidelines for structuring of a humanities and social studies curriculum running through the entire elementary and secondary sequence." Participants included some 61 persons representing social science disciplines plus those of law, history, physics, and education.

A report on the conference, *A Narrative Report 1962-1964 Social Studies Curriculum Program*, November 1964 concluded that, ". . . the teaching of the general field of social studies and the humanities is desperately in need of improvement in the elementary and secondary schools of this country."

Proposals from Educational Services, Inc., and the American Council of Learned Societies (ACLS) received by the National Science Foundation on January 3, 1963, described a review of 250 existing social science films conducted in August-September 1962 by ESI and ACLS staff which resulted in criticisms regarding the minimal involvement of social scientists. New projects were proposed which would deal with these shortcomings by having films made by social scientists and reviewed by experts; by developing films that could be used for children at all grade levels and would be edited for viewing by a general audience. The films would provide a flexible format and would be limited to that data which could be best represented on film leaving much to the student to be interpreted, and which would also experiment with film innovations.

In addition, two conferences supported by the Office of Education and NSF were sponsored by the President's Scientific Advisory Committee (PSAC). Results reinforced the conclusion that there was an urgent need for course improvement in the social sciences and led to recommendations that the NSF support social science curriculum development projects.

Today, MACOS materials are estimated to be in use in about 1,700 schools in 47 states. Estimates of students affected range from about 200,000 to 328,000. The materials are also being used in five Canadian provinces and in England, Scotland, North Ireland, and New Zealand. One report estimates that in 1970 the MACOS materials were being used by about 200,000 children and that the number of schools using the materials had increased from approximately 375 in 1967 to nearly 1,700 in 1970.

Materials on community response are mainly newspaper accounts, reports of very small-scale mail surveys, or anecdotal information. These materials do indicate that MACOS was a subject of controversy as early as 1971 and that NSF social science projects received cautionary Congressional comment in the mid-sixties.

Review and Oversight History

Prior to its support of MACOS-related projects, NSF supported development of secondary curricula in anthropology. Each major MACOS-related award was subject to staff review and/or peer review, and was submitted, as revised on the basis of those reviews, to the National Science Board for approval. It appears, then, that in the judgment of scientific peer reviewers, representatives of the educational community, staff of the Education Directorate, and the National Science Board that the proposed subject matter did fit within reasonable limits or norms with respect to educational value. Further, there appeared to be no questions on accuracy of content nor doubt about competence and experience of the developers.

The proposals that led to the development of the MACOS curriculum in 1963 requested $284,200 for the preparation of anthropological films. All four proposals were submitted to peer review. Awards were made for two projects; the other two proposals were withdrawn in August 1963. The awards did not involve either policy issues or levels of funds requiring NSB approval.

On the advice of NSF staff, the same grantee organization submitted a consolidated proposal requesting $618,315 for additional work on the two projects that had been supported and for incorporating work described in the two proposals that had been withdrawn. This consolidated proposal was not submitted to peer review; NSF staff recommendations for support were based on results of evaluations of the separate proposals that had received peer review earlier. The staff recommendation for support, at a reduced budget level, was submitted to and approved by the National Science Board.

All subsequent proposals for continued substantive work received peer review and or review by NSF program staff. In each instance, the program staff summarized the major issues raised by reviewers and made recommendations for support to senior staff of the Education Directorate. In each instance, the recommendation was for a lower level of effort than had been proposed and was submitted to and approved by the National Science Board.

Monitoring History

The primary means of monitoring the MACOS projects appears to have been peer review and staff review of the proposals submitted for specific work elements. These reviews resulted in modifications in the budgets requested and occasionally resulted in modifications in the scope of work. There appear to have been only two site visits conducted during the course of the MACOS curriculum development. Major responsibility for the conduct of the work was with the principal investigators and a planning committee of social scientists and educators that was assembled by the grantee.

Review suggests that monitoring of the project has been a comparatively weak point in management of the MACOS project.

Contractual Arrangements

Because of the unusual nature of the MACOS project and the teacher training requirements which Educational Development Center (EDC) insisted on being written into the contract, the task of locating a suitable publisher was very difficult. The contractual arrangements between EDC and Curriculum Development Associates (CDA) which finally evolved, though somewhat at variance from the norm, appear to be fiscally sound and adequate for the purposes intended.

Dissemination/Implementation Plan

Major difficulties were encountered by EDC in developing and carrying out dissemination and implementation of MACOS curriculum. The publishers believed the program had four major liabilities that made marketing it a risk of capital, time, and personnel.

- Unconventional concepts of the course;
- The need for special teacher education;
- The interrelatedness of media with function;
- The cost of the program.

In 1969 and 1970 (prior to EDC obtaining the services of a publisher) NSF supported a small number of regional centers strategically located in universities and colleges in Florida, Oregon, Colorado, Connecticut, New York, and other states. The purpose of these centers was to furnish information concerning the MACOS curriculum in the school districts in the region. When schools expressed the wish to utilize MACOS curriculum, appropriate teacher training was provided by the centers. These centers were supported by the Course Content Improvement Program for three years beginning in FY 1969 and were discontinued shortly after CDA contracted to publish and disseminate MACOS curriculum.

Because of the innovative nature and unconventional concepts of the course, EDC felt strongly that teachers should receive specific training prior to teaching MACOS in the school systems. As a result, EDC made this a requirement for publishing the course. CDA officials stated that they would "be insistent on a method and program of dissemination which provides the teachers who use the Course with full exposure to the use potentials conceived of by those who have developed it;" and would "seek a financial arrangement which provides maximum opportunity for further development by the Center (EDC) of this and other teaching-learning courses."

CDA was given full responsibility by EDC to develop the production and dissemination program. The Price Information Sheet for materials developed for MACOS contains the following statement: "All orders for classroom or film materials are subject to verification by CDA that the purchaser has complied with teacher education requirement necessary for proper implementation of the *Course.*" NSF provided support for teacher training for MACOS through its Summer Institutes Program, its Course Content Improvement Program, and its Cooperative College School Program. A multiplier effect is considered to be highly desirable by EDC, and trained personnel are expected to return to their school districts and train other teachers in the effective teaching of the MACOS course, as is the case with many implementation projects supported by NSF.

At the present time NSF does not fund any regional centers for dissemination/implementation and NSF staff have repeatedly asked EDC to delete reference to NSF support of "regional centers" from its publications.

Detailed discussions of financial arrangements, implementation, and diffusion methods are found in the MACOS case study, Appendix 4, along with staff comments on procedures to date and perceived problem areas.

SYNOPSIS OF COMPARING POLITICAL EXPERIENCES (CPE) REVIEW

The American Political Science Association proposed to establish a Political Science Course Content Improvement Project for elementary and secondary schools to design and develop new instruction materials for teaching government and politics in elementary and secondary schools. The Political Science Course Content Improvement Project was to consist of two components. One, the High School Political Science Curriculum Project, to develop instructional materials for use in senior high school civics and government courses; the other, the Elementary School Political Science Curriculum Study Project, has undertaken a study of political science education in elementary schools and, on the basis of this study, developed a set of guidelines for the production of new instructional materials and media for grades kindergarten through six. They were designed to be used either in conjunction with existing curricula or as new programs in political science education. However, in winter 1975, the decision was made not to support the elementary school project after the first year.

The high school project material was in tryout in 1974 and the second semester material is in preparation. The exact nature of publication is not yet determined. It may be one hard cover textbook or a series of separate units.

Presently there are twenty-five pilot schools using the course material. There are also fifty affiliate schools which receive the materials but are only informally involved in pilot testing.

Review and Oversight History

The determination was made by NSF that political science is an appropriate subject material for the Foundation. Verification as to the accuracy of the scientific content was a responsibility of APSA in its activities in monitoring the curriculum development. At later stages, some portions of the material were distributed to reviewers or summarized in renewal proposals and comment was obtained regarding scientific content. Based on the comments of the reviewers, co-project directors were found to be highly qualified professionals and there were no questions as to their competency.

Monitoring History

No site visit was made prior to the award of the grant on March 13, 1972. A site visit was later made to Indiana University, a subcontractor to APSA.

Possibly, because this project is in its early stages, there has been continuity on the part of the NSF program office personnel and reasonable attention to monitoring of the program. Not unlike other grants, the major reviews occur annually when requests for additional funds are received. No specific oversight committee was appointed by the Foundation. The fact that the American Political Science Association was the named grantee, with responsibility for the overall coordination of the effort, appears to have led to the conclusion by NSF staff that the need for such a function was met.

Contractual Arrangements

Indiana University held a publishers conference in July of 1974 to present four Social Studies Development Center projects to potential publishers. The University was furnished with a copy of the Foundation's publication policy, which required approval of the plan to announce the availability of materials to all qualified distributors; selection of a particular publisher; and finally the proposed contract between the publisher and the grantee. A second conference is planned for fall 1975 to present more definitive material, and then to invite specific proposals.

Dissemination/Implementation Plan

The dissemination and implementation plan has not been fully developed at this point, but it appears that it will conform to NSF requirements.

SYNOPSIS OF INDIVIDUALIZED SCIENCE INSTRUCTIONAL SYSTEM (ISIS) REVIEW

The ISIS project is focused on developing a flexible, open-ended, interdisciplinary curriculum that will facilitate individualization of science instruction at the high school level.

ISIS will consist of approximately 80 short, essentially independent modules or minicourses, each requiring 2-3 weeks of classroom time. Each module will deal with a specific topic by presenting, in an interdisciplinary manner, the appropriate concepts from biology, chemistry and physics. Pertinent information from the social sciences will be incorporated in units that deal with the social implications of science and technology. Mathematics will be included when necessary. For all modules, "excursions" will be developed which will permit the student to probe into some of the more complex aspects of the topic. In an effort to keep down the equipment costs for schools adopting ISIS, the laboratory work will make use of materials and apparatus normally available in high school science labs. Guidance in implementing ISIS under a variety of situations will be provided by an instructional management scheme. Twenty-nine minicourses are now in the trial stage of development and are being field tested in several high schools throughout the United States.

According to the project director the ISIS minicourses will not simply be a set of plans, but rather will be complete learning packages containing everything the teacher needs to provide students with individualized science instruction. The ISIS developers feel that such a complete package will free the teacher from much of the routine of a classroom and allow the necessary time for interaction with individuals or small groups. A few of the topics to be included are: buying and selling, people pressure, seeing colors, ways we learn, heart attack, house plants, home electrical appliances, fire and explosion, and energy supply and demand. Other courses are proposed and are being readied. Two trial minicourses, "Human Reproduction" and "Birth and Growth" have in one case (Dallas, Texas) been refused by a trial center.

ISIS trial materials are currently being used by more than 10,000 high school students attending the ISIS trial center schools located throughout the U.S. It is still too early to assess the actual impact of the ISIS program since no final versions of minicourses have been developed. According to the ISIS developers there is already a high demand for ISIS materials, and they plan to release minicourses as they are completed.

Review and Oversight History

In a grant dated June 23, 1971, NSF provided support for a conference held in October 1971 at Callaway Gardens, Georgia, which brought together 34 experts to explore the feasibility of a new approach to high school science. The persons attending the conference represented a very wide range of experience in science and school instructional materials development. Every branch of the teaching profession was represented including classroom teachers, science supervisors, school administrators, professors of science education and learning theorists. There were also representatives from various professional organizations. The conference participants cited what they felt was considerable evidence for the inability of the then current science programs to meet the needs of today's society, today's schools, and today's students.

Criteria for reviewers included that they represent a cross-section of disciplines, be prominent in their field, and required that they have experience in pre-college education. They were asked to base their evaluations on the merit of the idea, the feasibility and effectiveness of the procedures, the qualifications of project leaders and on budget factors.

Two oversight committees were initially set up, but have been replaced by an advisory board that seldom meets as a unit, but in subgroups which concentrate on the areas of their expertise. Board members are listed in the case study, Appendix 4.

The principal investigator has expressed the opinion that a summative evaluation could not be made for at least seven years to determine what happens to children as a result of being exposed to a fully developed product. Further, criterion referenced testing is recommended rather than normative testing. The object is to determine how many children meet some specific criteria rather than to see if they achieve a given score on a test. Step-by-step details of the evaluation process are found in Appendix 4.

In the course of the detailed examination of ISIS the internal documentation leading to the award decision was reviewed. In particular, it was observed that, as is often the case, the written peer reviews formed only a part of the process. After analysis of the reviews, the program staff made the essence of these reviews available to the ISIS project team. The ISIS team then responded at some length to the critical views raised by the reviewers. In addition, the ISIS staff met with NSF staff to further clarify various points. The program staff recommendations reflected these discussions in detail and indicated a staff decision that these interactions dealt effectively with the critical reviewer comments. The recommendation for an initial trial phase with a subsequent decision-to-continue being contingent on an adequate indication of progress, is fully consistent with the review consensus.

Awards to continue the project were based primarily on staff evaluation of progress which included site visits, review of progress reports, and other oversight procedures.

Although the review and oversight is judged to be adequate, it is noted that the material provided to the NSB did not fully describe the interactions with ISIS staff which dealt with negative comments of reviewers. It was also observed that panel review of the initial and subsequent proposals might have had advantages over the mail review process. The observations are documented in the case study report, Appendix 4.

Monitoring History

The Foundation has monitored progress of the ISIS project through site visits, telephone conversations and correspondence. Results from a team of three outside reviewers will be used by NSF staff. Staff members have attended meetings of the ISIS Advisory Board and have reviewed all recommendations and actions of the group.

Contractual Arrangements

The commercial version of the program will be published by Ginn and Co. who will retain exclusive rights until December 31, 1984, after which the exclusive publication rights expire. All arrangements are reported to be satisfactory.

Dissemination/Implementation Plan

Current plans call for release of completed minicourses in groups of 15 to 20 over the next five years. The first lot of 10 will be released this year. With the release of subsequent minicourses, the possibilities for clustering them to build several varieties of courses for students of all abilities will increase and ultimately there will be many disciplinary as well as multidisciplinary course possibilities. By 1979 the ISIS developers expect to have published enough minicourses to allow schools who wish to do so to totally replace their high school science programs with one of many locally determined alternatives.

OBSERVATIONS

These observations stem from consideration of materials prepared in the course of the study, and relate this information to our understanding of the practices in program management and program development in this and other Federal agencies. Practices of the school systems of the Nation and of the industries that supply them with material were reviewed and views of the scholarly community were also noted. Specifically, the detailed case studies undertaken provided the opportunity to examine the nature and character of NSF program procedures as they have evolved and have been applied in the course of curriculum development activities.

Observation 1: It is widely believed that this program has been instrumental in bringing about a major change in the content of science teaching materials at the pre-college level. This has stimulated related creative efforts in development of teaching materials in other Federal agencies, in the industry, and in the school systems themselves.

Observation 2: There have been extensive changes in the national situation with respect to pre-college curricula over the lifetime of this program which began, essentially, in 1958. Program guidelines and policy have been revised as the climate changed and as NSF staff and the National Science Board became increasingly aware of the very complex issues associated with the dissemination and implementation of course materials. The policy framework has evolved in a manner that reflects changes in the external situation. However, no comprehensive review of future needs for pre-college curriculum seems to have been carried out in any breadth and depth. Current program emphasis is on completing and implementing the array of courses already under development; very little attention is being given to initiation of new courses during this present period of stocktaking.

Observation 3: NSF program staff has conformed with acceptable and current procedures and policies since the inception of these programs. However, climate in the Federal Government with regard to program accountability, openness and the involvement of outside affected parties implies a need to consider a substantial reexamination of the policy framework for this program and of the management procedures which are in use.

Observation 4: Operational management decisions made by the NSF pre-college science education program staff reflected acceptable practices, procedures and policies that existed at the time the decisions were made. During examination of project files and documentation only minor uncertainties in project management decisions could be found, and these were few.

Observation 5: General management practices as applied by NSF offices external to the pre-college science education programs were essentially consistent with existing policy framework and procedures. There are, however, alternatives which could be considered to improve the effectiveness of NSF programs and which, in some cases, are contingent upon changes in policy. Other improvements can be effected by internal strengthening of current practices.

Observation 6: The operational and management practices of the pre-college curriculum program reflect steady and consistent improvement over the past decade. Nevertheless, further improvements in program management practices are still desirable and should be considered. Some of these are:

- strengthened monitoring of projects through site visits, telephone contact, and other techniques
- improved attention to the determination and definition of run-out costs
- strengthened evaluation procedures
- more extensive and detailed review of legal and business matters
- more clearly established criteria for general program practice.

POLICY ISSUES

Although the foregoing observations indicated that the management and decision processes in this program have been adequate in the context of existing policy and practice, there are questions both of policy and of management practice that require increased attention. In retrospect, as with any judgmental process, there were errors both of individual judgment and of administrative practice of a type which can be reduced by diligence but never eliminated. More serious are major policy issues which have been considered at times in the past but which have not been fully resolved or which now require reexamination.

The review team has identified five general policy issues which should be addressed in determining the future course of this program. These are:

1. Redefinition of the NSF role in science curriculum development
2. Determination of future needs
3. Awards process
4. Proposal review
5. Curriculum implementation

These policy issues were identified in the course of the study, and reflect the flow of activities in curriculum development and implementation. They were presented to and discussed in detail with the Advisory Committee on Science Education. The Committee's recommendations along with those of the review team are found in Section III.

Policy Issue 1.

REDEFINITION OF THE NSF ROLE IN SCIENCE CURRICULUM DEVELOPMENT

For both the natural sciences and social sciences, present and future goals and objectives require examination and a statement is needed to define more clearly whether the program should be directed toward education of future scientists, science education for all citizens, or both.

BACKGROUND

The pre-college science curriculum development and implementation programs arose out of the perceived need in the late 1950's for major improvement in the science content of public education. This was stimulated, in part, by the advent of Sputnik and also by the view of most scientists and educators that the scientific training of students entering college was weak and that the content of pre-college courses and texts was out of date. As a result, the initial courses supported by NSF were proposed by, and came to be directed by, scientists with extensive research experience and established scientific reputations but with relatively little experience in the elementary and secondary classroom environment. This early trend led to some major successes but also created certain problems. Some of the early courses developed with NSF support were judged by schools to be too esoteric for a great number of students. Others were able to receive only limited distribution; local school systems were reluctant to adopt them because of their novel features, difficult content and the need for extensive teacher training or retraining.

Examination of early projects shows that review of the content and intent of the program was performed almost entirely by research scientists whose principal concern was for the substantive content of the course rather than for its teachability, and who lacked familiarity with the milieu in which it would be used. By contrast, many of the reviewers of recent projects are classroom oriented teaching professionals from local school systems and teacher's colleges.

There seems to be adequate evidence that a major shift in pre-college science curricula has taken place. A key question, however, is the extent to which further Federal support is, in fact, needed. Therefore, it is suggested that a redefinition of NSF goals and objectives in pre-college programs is in order.

One of the crucial issues is whether projects should be oriented toward providing the base of experience in science methodology, attitudes and content primarily for those students who will be the future scientists of the Nation, or whether they should be oriented towards science education for the general citizen. It must be noted that many individuals who will receive advanced scientific training in college will not themselves become research scientists but will work in a wide variety of science-related jobs. It appears that the scientific pre-college needs of these students may not have been adequately met, and it is felt this need merits more extensive evaluation. Still, these two groups are surely outnumbered by those individuals who will not study advanced science intensively or at all.

The question of who should receive intensive pre-college scientific training is particularly germane in the natural sciences where an early start toward scientific creativity is often considered to be exceedingly important for future scientists. Conversely, such an intensive introduction to the substance and method of science might not be appropriate for the individual who is unable to perceive a need for scientific education.

In addition to the question of which students should receive such scientific training, course content must be considered carefully as well as the proper grade level for introduction.

Development of social sciences curricula demands particular awareness of the ways society views values that may be associated with the subject matter. This can substantially affect acceptance of courses, or at least public perception of them.

It is to be hoped that a redefinition of the NSF role in these programs involving participants representative of all disciplines, from both academe and the classroom, will aid in determining what NSF should do as well as what it should not.

Policy Issue 2:

DETERMINATION OF FUTURE NEEDS

Establishment of broadly-based review groups would allow assessment of pre-college curricula through integrated studies; new starts could be deferred pending this review of needs. Other systematic approaches to needs assessment could be explored.

BACKGROUND

It would appear desirable to carry out broad based analyses of future needs for science curriculum development at the pre-college level. This could be done in a variety of ways; for example, contracted studies and surveys could be undertaken which would examine the attitudes of special groups—teachers, school administrators, scientists, and others. Alternatively, conferences or symposia could be planned for each discipline; or congressional hearings could be held where expert testimony is presented by all interested parties. Possibly NSF could charter a special commission to examine needs in science curriculum development, or the Advisory Committee for Science Education or other outside groups could be organized into task groups to specifically examine these needs.

At this stage it is proposed that a very broad needs assessment be undertaken that would cover the spectrum of science disciplines for students of all ages at the pre-college level. Such an assessment could then be followed by individual discipline assessments or other specific assessments after a need is identified in the broader scope. This would narrow the range of anticipated teacher-curriculum development projects to a relatively manageable number. The process could be designed to tap the experience of scientists, educators, and citizens otherwise involved in the educational process and would allow them to work toward a mutually agreed upon assessment of needs and requirements.

Policy Issue 3.

AWARDS PROCESS

Contingent on the systematic assessment of needs, an NSF program decision to proceed in a given area could be broadly disseminated to allow an open competitive process for selection of awardees as compared with the customary NSF practice of responding to unsolicited proposals.

BACKGROUND

The process by which NSF makes grants for curriculum development is patterned rather closely after the traditional NSF approach for research grants; however the tasks undertaken are very different. Research projects are tailored to suit the individual investigator and his innovative ideas, while a curriculum development project requires a team effort over a number of years to ultimately produce an educationally useful and commerically viable product. The present NSF approach of responding to unsolicited proposals from interested parties in the community may today be inappropriate.

From another viewpoint, the use of the full machinery of Federal procurement contract regulations for the development of curricula might be equally as inappropriate. These procedures require arm's length competitive processes which would make it quite difficult for NSF staff or advisors to work with those submitting proposals to aid in defining and improving programs, and would limit the degree to which subsequent changes in the program could be effected without exhaustive and detailed review.

There are, however, intermediate procedures. For example, based upon a broad general needs assessment and subsequent specific assessments, the technique of program annoucement or program solicitation could be employed wherein areas of interest and general requirements for programs are identified, leaving proposing institutions or consortia free to propose or not propose after needs have been identified. Most often in the past, those who have identified the needs through a conference or other process have become the agents in constructing a large proposal and there has been little opportunity for direct competition.

A phased, step-by-step process, in which two or three or more projects for program definition would be supported might yield a variety of different approaches to a given problem. A restricted proposal competition could then follow in which the small number of groups who had defined the problem would be invited to develop a full-fledged proposal and would receive support for this purpose. From these, one awardee might be chosen. This process could conceivably produce a more highly developed plan for each project; one which would result in an improved structure to permit evaluation and oversight. Similar techniques have been used by other agencies of the Federal Government and by the RANN program at NSF.

Policy Issue 4.

PROPOSAL REVIEW AND PROJECT EVALUATION

Procedures for external, independent evaluation of project progress and content at all stages of development are important to ensure their accuracy and usefulness. These procedures could be strengthened and might include participation of practitioners and other "users." Such evaluations could take into account problems, needs and perceptions at the local level.

BACKGROUND

Evaluation of curriculum proposals has customarily taken place in a manner analogous to basic research proposals, that is, individual proposals are usually sent to mail reviewers, and these and other reviewers are sometimes used as consultants on proposal site visits. Evaluation of the content of ongoing projects is often carried out by an advisory board or steering committee that works with the director of the project. A major project may undergo three or more external peer evaluations in various stages of its funding over a period of seven or eight years. Curriculum development proposals might better lend themselves to panel review than to mail review—particularly if well defined review criteria are in use. However, this method might raise the question of cost effectiveness.

There has been an increase in participation of practicing educational professionals in NSF evaluation processes, but by and large, the evaluation of content has been left to the project team. Although material is subject to peer review, the question is whether it might not be desirable to have an independent third party advisory board or panel check on the content and progress of major projects, particularly of courses that may have value-laden content. At the end of the development process, independent third party evaluation might be particularly useful.

Policy Issue 5.

CURRICULUM IMPLEMENTATION

One approach is for implementation to be supported only after an independent, impartial external review has been undertaken covering need, content and potential benefit. If NSF is to continue to support implementation, the following elements are worthy of consideration:

- well defined review mechanisms for judgment of content,
- a more clearly defined process for dissemination/implementation,

- more definitive policies on rights, royalties, exclusivity, and fiscal arrangements,
- mechanisms for NSF review of decision to proceed with implementation including periodic review by NSF.

BACKGROUND

An analytical study of research on curriculum implementation carried out as part of this study[1] has shown that "the successful implementation of innovations is generally considered to require a degree of change, capability and motivation not typically found in schools." It indicates that "early and meaningful involvement of those who will implement change" is essential, frequent communication with the users of materials is necessary and that training or involvement of all levels of the user system, teachers, administrators and field of study specialists is essential. NSF has used many mechanisms to deal with these matters, including special institutes for administrators and teachers and the regular program of teacher training institutes.

The issue of curriculum implementation is not clearly faced in the present program, but is dealt with *ad hoc* when each curriculum approaches the implementation stage. It is customarily assumed that implementation is an essential goal. However, there has not generally been a conscious, carefully designed evaluation of the product prior to the decision to proceed with implementation of the program.

Because implementation involves precisely that phase of the program that might be labeled "promotion" or "marketing", an explicit policy statement on the extent of implementation appears to be needed. It is probably desirable to have a much more carefully delineated stage of, first, the decision to implement and second, the plan or scheme by which implementation is carried out.

One approach worthy of consideration would be to undertake implementation or dissemination review jointly with the Office of Education and the National Institute of Education. It should be recognized that implementation has long been a matter of serious concern both to the NSF staff and to the National Science Board and that most of the possibilities that have appeared reasonable have long been subject to trial and error and have often met with success.

Of particular importance is the refinement of business policies in order to ensure that NSF practice is fair and equitable, including development of greater consistency with practices in other Federal agencies.

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[1] Sikorsky, Linda A., An Analytical Summary of Knowledge About Curricula Implementation in U.S. Schools April 29, 1975.

III. Recommendations

ADVISORY COMMITTEE FOR SCIENCE EDUCATION RECOMMENDATIONS

On May 9-10, 1975 the Advisory Committee for Science Education met for the prime purpose of reviewing the findings and observations of the science curriculum review team. The Advisory Committee focused its efforts on the policy issues raised by the review team and its recommendations are structured in response to those issues. The report of the Advisory Committee as made to the Director, NSF, is included in its entirety.

ADVISORY COMMITTEE FOR SCIENCE EDUCATION REPORT

At the request of Dr. H. Guyford Stever, Director, National Science Foundation, the Advisory Committee for Science Education met May 9-10 to hear and consider the draft report of the NSF science curriculum review team. This *ad hoc* study team, headed by Assistant Director Robert E. Hughes, provided an extensive report to the Advisory Committee. In order to have an outside opinion, as requested by Dr. Stever, the Advisory Committee considered the five major policy issues raised in the report. The Advisory Committee has submitted the following recommendations to the Director.

1. **The NSF has a continuing role in science curriculum development in the mathematical, physical, medical, biological, engineering, social, and other sciences at the pre-college level, insofar as these subjects can be addressed appropriately at that level.** In view of the NSF's contacts with the scientific community in research and education, the Foundation can make a unique contribution by bringing new, intellectually challenging science content, and teaching methods to elementary and secondary school students and their teachers. The program should be broadly aimed toward encouraging future scientists and technicians as well as preparing all citizens who will face increasing demands for informed decisionmaking with regard to the impact of science and technology on their lives. In pursuing this role, the Foundation should be mindful of the fact that the final decision regarding the use of instructional materials and curricula is made locally. In other words, the schools must have genuine options from among which they may select the approaches most suitable to address local needs and circumstances.

   It should be recognized that much educational innovation is, by its nature, controversial. It therefore follows from the Foundation's educational mandate that the Foundation cannot and should not attempt to avoid controversy at the expense of educational or scientific values in the creation or development of new materials.

2. **The NSF should take an active and continuing role in determining needs for improvement of pre-college science education.** The needs analysis will include

solicitation of suggestions from the scientific research community in traditional and interdisciplinary areas, elementary and secondary school teachers, school administrators, science educators, students, and parents. While comprehensive needs analyses are in progress, the Foundation should continue to consider proposals and make grant awards where the need has been clearly identified. The results of the needs analyses should receive wide distribution to the public and will provide a basis for future program development.

3. **The NSF should avail itself of a broad range of granting mechanisms.** They should continue to accept unsolicited proposals and should expand the use of "program solicitation" procedures. Program announcements should specify the criteria for evaluation and selection.

Curriculum development projects cannot always be judged by the usual "peer group" used in research project review. When appropriate, reviewers should include experts in the subject matter, in the process of teaching that material, in project evaluation, and in the administration and management of such long term efforts in school systems.

The NSF should be alert for unsolicited proposals that may be of high quality, but limited applicability (e.g., excellent curricula dealing with local ecological systems). The individual who works out such curricula may not be aware of NSF procedures and may need special help to become involved in the granting process.

4. **All large scale project proposals should include a detailed plan for evaluating the progress of the project at specified times during the course of the work. The NSF should provide for external summative evaluations of all major projects.**

Criteria of evaluation should include factual data, estimates of levels of performance and educational significance, cost effectiveness, and degree of non-NSF support provided.

One technique for external evaluation which should be considered by NSF is the use of third parties to engage in a debate of the merits and weaknesses of the project. These debates could be used to identify not only weaknesses of factual content, but possible questions of "propriety of content" in the anticipated use of the material. This debate might be carried out before any widespread dissemination of the curriculum is undertaken and a summary of the pros and cons might accompany the materials as they are disseminated.

Students who have actually participated in these programs could be interviewed to include their reactions to the program.

5. **To assure availability to the public of Foundation supported curricula and teaching materials, the developer should be strongly encouraged to make arrangements for the publication, manufacturing, and marketing of these curricula or materials without the requirement of Foundation funds for these programs.**

To improve teaching practice in science, the Foundation should support outstanding projects for teacher education and resource personnel development. These may concern the use of innovative curricula or material whose development was supported by the Foundation, but shall not be restricted to such materials.

CHAIRMAN, SCIENCE CURRICULUM REVIEW TEAM RECOMMENDATIONS

The following recommendations were submitted to the National Science Board and the Director by the chairman of the special review team Assistant Director, Robert E. Hughes. They represent the conclusions of the chairman after due consideration of the results of the study conducted by the review team. The chairman also consulted with two members of the National Science Board who were associated with the review team for oversight purposes and with the Advisory Committee for Science Education.

Procedural Recommendations

The following recommendations are procedural in nature. They are intended to strengthen ongoing practices and to develop a somewhat more formal, structured approach to curriculum development and curriculum implementation activities of the National Science Foundation. They can be implemented through normal administrative action, but this, of course, does not preclude the possibility that the National Science Board might wish to speak to these or related issues in a general policy statement.

1. **It is recommended that a continuing program be instituted to develop and establish priorities for curriculum development activities.**

This needs assessment program should utilize a variety of mechanisms such as panels, conferences, symposia, workshops, etc., to develop priorities within and among prospective disciplinary and interdisciplinary areas. These activities should include representatives with professional experience in education, curriculum development, and in the disciplinary fields of interest. Active participation should also be solicited from school administrators, teachers and the interested public.

2. **It is recommended that procedures be developed to guarantee: (a) that information is widely disseminated about needs for curriculum development activities that have been identified in certain specific or broad areas (b) that proposals received in response to such announcements are reviewed by appropriate panels in a competitive mode; (c) that the review panels are carefully constructed to provide a sound intellectual base and reasonably broad representation; (d) that, when appropriate, several of the best proposals be funded as pilot programs for approximately two years, after which time another competitive review should be conducted to determine whether one or more of these should be continued.**

Many innovative and important ideas and programs arise from unsolicited proposals from individual investigators. It is vitally important that neither the needs assessment program nor the competitive review procedures be structured so as to discourage or preclude the submission of independent ideas to the National Science Foundation.

3. **It is recommended that more formal, structured procedures be established for periodic review of major curriculum development programs.**

These reviews are not to be confused with "formative evaluation" or "summative evaluation" activities that are undertaken by the grantee as a normal part of the curriculum development activity itself. The reviews should be structured by NSF to include appropriate professional and public representation and should be directed toward an assessment of the merits of the total development activity. The review activity should involve an interactive panel and, whenever appropriate, an on-site visit with the grantee. Special care should be taken to ensure that the review panels, while free to express their views, do not stifle freedom of intellectual inquiry and innovativeness on the part of the investigators.

4. **It is recommended that a formal mechanism be established for conducting an in-depth review of completed curriculum development programs.**

The review panels should be carefully structured to provide balanced professional oversight and appropriate public representation. Such a review should be mandatory before curriculum implementation activities are considered. This should not preclude normal testing activities within selected school communities for the purpose of developing and revising elements of the curriculum programs.

5. **It is recommended that a research program be developed to carefully explore existing barriers to diffusion of new curriculum materials in science education.**

The program should be structured to provide basic information about the total system. The information should be made available to the Congress, Federal agencies, State and local authorities, the educational community, and the curriculum development community.

Total responsibility for adoption of curriculum materials in school systems rests with local and State authorities. There appears to be widespread concern among many professional and public groups about the complicated process of introducing new curricula into local school systems. It is important that all interested parties fully understand every aspect of the curriculum implementation process in order to ensure that Federal activity in this area does not infringe upon local and State responsibilities.

6. **It is recommended that a legally binding codicil be added to every curriculum development grant to ensure that the grantees comply with the existing provision that a disclaimer of NSF endorsement be prominently displayed on all materials developed under the grant.**

Although such a disclaimer is called for in the NSF Grants Administration Manual, it appears that the requirement has been ignored in some cases. This is an important issue and the disclaimer should be made mandatory with legally binding agreements.

Policy Recommendations

1. **It is recommended that the National Science Board develop a definitive policy statement that speaks to the purposes and the objectives of curriculum development activity at the National Science Foundation.**

The fundamental objectives of curriculum development activities at the NSF have gradually changed over the years. At first, the primary objective was to design curricula to attract the best minds and to improve the educational attainments of those students in secondary and primary school systems who were likely to embark upon careers as professional scientists. Gradually, another objective gained widespread acceptance. This involved a deliberate concern with providing a deeper understanding of the impact of science and scientific thinking on modern society to *all* students at every educational level. The first approach is directed toward developing competence in specific intellectual disciplines; the second toward illuminating the underlying nature of our technological world. The policy statement should delineate the extent to which future science curriculum activities at NSF should be directed toward these goals for both the natural and the social sciences.

2. **It is recommended that the National Science Board formulate a clear policy statement on the role of the National Science Foundation in the implementation of science curricula.**

In the public at large, in Congress and in the local and State educational communities there are widespread convictions that the role of the social sciences in school programs differs in some fundamental way from the role of the natural sciences. Traditionally, in many quarters, the social sciences have been regarded as a key element in introducing young students to the social and political environment in which they will live and work. Indeed, courses in local, State and Federal government—civics, history, and geography—have often been directed to that end. From this point of view, attempts to introduce alternative approaches to the social studies are sometimes regarded as having political implications.

Concern over new and controversial ideas is, of course, not limited to the social sciences; possible impacts of new developments in the physical and natural sciences have long been debated. In both cases, such concern is heightened whenever the Federal Government appears to be using its resources to deliberately disseminate or promulgate controversial material.

Since curriculum implementation activities are designed to disseminate materials that are sometimes regarded as controversial or even inherently political in nature, it is important that a clear NSF policy be developed for the guidance of future activities in this field.

3. **It is recommended that the National Science Board initiate a study to develop new mechanisms for administering curriculum implementation activities that will allow the National Science Foundation to remain at "arm's length" from the process.**

Analyses of the overall impact of NSF sponsored curriculum developments in the sciences suggest that there has been widespread acceptance of many of the programs in the Nation's school systems. The national educational establishment is not only huge, it is remarkably diverse and highly decentralized. It is generally accepted that organized curriculum implementation activities are necessary if new developments are to be brought to the attention of local authorities for their consideration. Thought should be given to new approaches that might directly involve State and local authorities, private institutes or academics in curriculum implementation.